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Conceptual Hydrogeologic Model for 300 West LLC/Arnold

I. Introduction

The purpose of this document, developed by Richard P. Cobb, P.G., Illinois Environmental Protection Agency (Illinois EPA) (See Appendix I), is to describe a conceptual hydrogeological model to explain how volatile organic compounds (VOCs) such as 111 Trichloroethane (111 TCA) and associated stabilizer and corrosion inhibitor 1,4 Dioxane (1,4 D), Perchloroethylene (PCE), and Trichloroethylene (TCE) used as metal degreasers at 300 West LLC/Arnold (300 West or Arnold) moved/is moving through the soil to on-site Class I: Potable Resource Groundwater (35 Ill. Adm. Code 620) and migrated/is migrating to off-site Class I groundwater, private water supply wells, and irrigation wells.

II. Executive Summary

The conceptual hydrogeologic model for this site is, as follows:

- Sand and gravel conducts water (and contaminants) easily;
- Sand and gravel exists at the site and extends to the Kishwaukee River;
- Water flows down gradient;
- Contaminants in the water spread laterally and vertically;
- Contaminants also sink and pool on sandy silt and sandy clay at the site and these contaminants continue move slowly to sand and gravel down gradient;
- People who worked at the facility have testified that it was the “practice” to put contaminants on and in the ground;
- Up gradient background wells have not detected contaminants;
- Concentrations of contaminants are high at the facility; and
- Concentrations get lower as you move in the direction of groundwater flow.

To date, the full extent of the down gradient groundwater contamination plumes have not been fully delineated since contaminants are still being detected in off-site monitoring and irrigation wells.

The following provides the technical basis for the executive summary of the conceptual hydrogeologic model. A separate chronology of the documents, obtained via discovery by the Illinois Attorney General, that were used to develop this document was also developed.

III. Background

Morrison 2006 and Mohr 2010, states that the primary applications of TCA (methyl chloroform) were in cleaning and degreasing, where it served as a less toxic replacement for TCE, PCE, and other solvents. Moreover, Morrison 2006 emphasizes the following about TCA, 1,4 D, PCE and TCE:

Although TCA production in the United States occurred in the mid-1930s, the chemical did not see significant commercial use as an end product until the mid-1950s (Halogenated Solvents Industry Alliance, 1994). Its acceptance was tied to the development of suitable stabilizer formulations. Its production increased steadily throughout the 1960s and 1970s, and first surpassed the production of TCE in 1973 (Doherty, 2000b). Production peaked in the mid-1980s and then began to decrease due to increased environmental regulation and a heightened awareness of environmental impacts.

“The 1990s marked the beginning of the end of TCA’s use as a solvent, as its ozone-depleting potential caused it to be phased out under the 1990-amended Montreal Protocol and the 1990 Clean Air Act Amendments. Most emissive uses in the United States were phased out by the end of 1995.”

“Dow Chemical, the first and only major TCA manufacturer in the United States until 1962, introduced the Chlorothene brand of TCA in 1954 (USPTO). “

“In patents issued in 1954 and 1955, Dow registered the use of 1,4-dioxane (synonyms included DX, 1,4-diethylenedioxiide, diethylene oxide, p-dioxane, tetrahydro-1,4-dioxan, dioxyethylene-ether, and glycolethylene ether) and a nonprimary alkonol, the first effective TCA stabilizer system for use with aluminum (Bachtel, 1957). Chloroethene NU, introduced by Dow in May 1960, utilized the 1,4-dioxane-based stabilizer system (Chemical and Engineering News, 1962). “

“Approximately 90% of the 1,4-dioxane produced in 1985 was used as a stabilizer for chlorinated solvents, especially for TCA (United States Environmental Protection Agency, 1995).”
(Emphasis added)

Thus, as emphasized above the patented brand name of 111 TCA degreaser with a 1,4 D stabilizer and corrosion inhibitor was called **Chlorothene®**.

IV. 300 West Site Descriptions

ENVIRON 2004, 2006, 2011 indicated the following:

According to facility personnel, Building 1, which was demolished in 2002, was the first known structure developed at the site, likely in the late 1800s or early 1900s. Building 1 was reportedly present when the facility was operated as a rail yard and engine maintenance facility. A railroad spur was observed on the ground surface within the footprint of the former building at the time of the site visit. During Arnold's occupancy of the site, Building 1 was used for most of the magnetic component manufacturing operations conducted at the site at some point in its history, including current operations and Sintered Alnico magnet production (powdered aluminum, nickel and cobalt blending and pressing operations), Molypermalloy operations, maintenance and tool shops, and office operations. According to the 1993 PRC report, spent mineral spirits, trichloroethylene (TCE), and 1,1,1-trichloroethane (TCA) were generated at Building 1 during its history. In addition, facility personnel reported that the Arnold family built electrical transformers on-site in Building 1 prior to beginning magnetic components manufacturing in the 1950s.

Further, Environmental Group Services Limited (EGSL, 2009) provided the following description of the Arnold Site:

EGSL performed the site inspection on April 15, 2009 and was escorted by Ms. Jessica Wojick, Corporate Director of Environmental Health and Safety Affairs for *Arnold Magnetic Technologies*. The Subject Property is approximately 72-acres in size and is currently occupied by *Arnold Magnetic Technologies* (Arnold) which utilizes the property for the manufacturing of magnetic components and rolled metal products. The Subject Property was originally developed in the late 1890s and was first utilized as a rail yard and railroad engine manufacturing/maintenance facility. The Subject Property was reportedly purchased by Arnold in the early 1900s, with their magnetic operations/manufacturing beginning in the 1950s.

The following Subject Buildings are currently, or have been historically, located at the Subject Property (see Site Diagram in Appendix A):

- ✿ Building 1: Built in the late 1890s and demolished around 2002. Building was approximately 40,000-square-feet in size and was originally utilized for railroad engine manufacturing and repair. Arnold later utilized Building 1 for magnet production, pressing operations, and heat treating.
- ✿ Building 2/3/4/7: Original portion of the building (Bldg. 2) constructed in the 1950s, with subsequent additions (Bldgs. 3, 4, and 7) later constructed. The entire building is approximately 135,000-square-feet in size and is currently utilized for office space, maintenance, shipping, and miscellaneous storage. Building 2/3/4/7 was historically utilized for tape-core, powder-core, and winding operations associated with magnetic manufacturing; all manufacturing operations ceased in this building in approximately 2002.
- ✿ Building 5: Constructed in the 1950s-1960s and is approximately 74,000-square-feet in size. Currently and historically has been utilized by Arnold for their Alnico Products Division, which manufactures magnetic components by molting, melting, and finishing Aluminum, Nickel, and Cobalt.
- ✿ Building 6: Constructed in the 1950s-1960s and demolished in the 1990s. Building 6 was approximately 42,000-square-feet in size and was historically occupied by the Strontium Ferrite Department, which conducted wet processing, mixed metal sludge pressing, iron powder compressing, and baking/grinding operations associated with motor-arc manufacturing.
- ✿ Building 8: Constructed between 1950-1970 and is approximately 3,000-square-feet in size. Building 8 is utilized for the storage of landscaping and maintenance equipment, and also contains an approximately 850-foot deep water well that is utilized for potable water for the Subject Property; an associated 100,000-gallon above-ground water holding tank is located directly south of Building 8.
- ✿ Building 9: Constructed at an unknown date and demolished in the 1990s. Building 9 was approximately 5,000-square-feet in size and was utilized as an airplane hangar associated with an adjacent private runway (no longer present).
- ✿ Building 10: Constructed at an unknown date. Building 10 is approximately 3,000-square-feet in size is currently/has historically been utilized for miscellaneous storage, 55-gallon drum storage, and drum cleaning.
- ✿ Building 11/14. Original portion of the building (Bldg. 11) constructed in the 1950s, with subsequent addition (Bldg. 14) later constructed. The entire building is approximately 54,000-square-feet in size and has been utilized by Arnold's Rolled Products Division since the late 1960s. Operations that currently exist within Building 11/14 involve the rolling and finishing operations associated with the production of thin-gauge rolled steel products.
- ✿ Building 12: Constructed by 1970 and is approximately 14,000-square-feet in size. Currently and historically utilized as a parts/storage warehouse.
- ✿ Building 16: Constructed after 1987 and is approximately 3,200-square-feet in size. Currently and historically utilized as a hazardous and non-hazardous storage shed.

Weston 1994 includes the following map of the layout and buildings at Arnold:

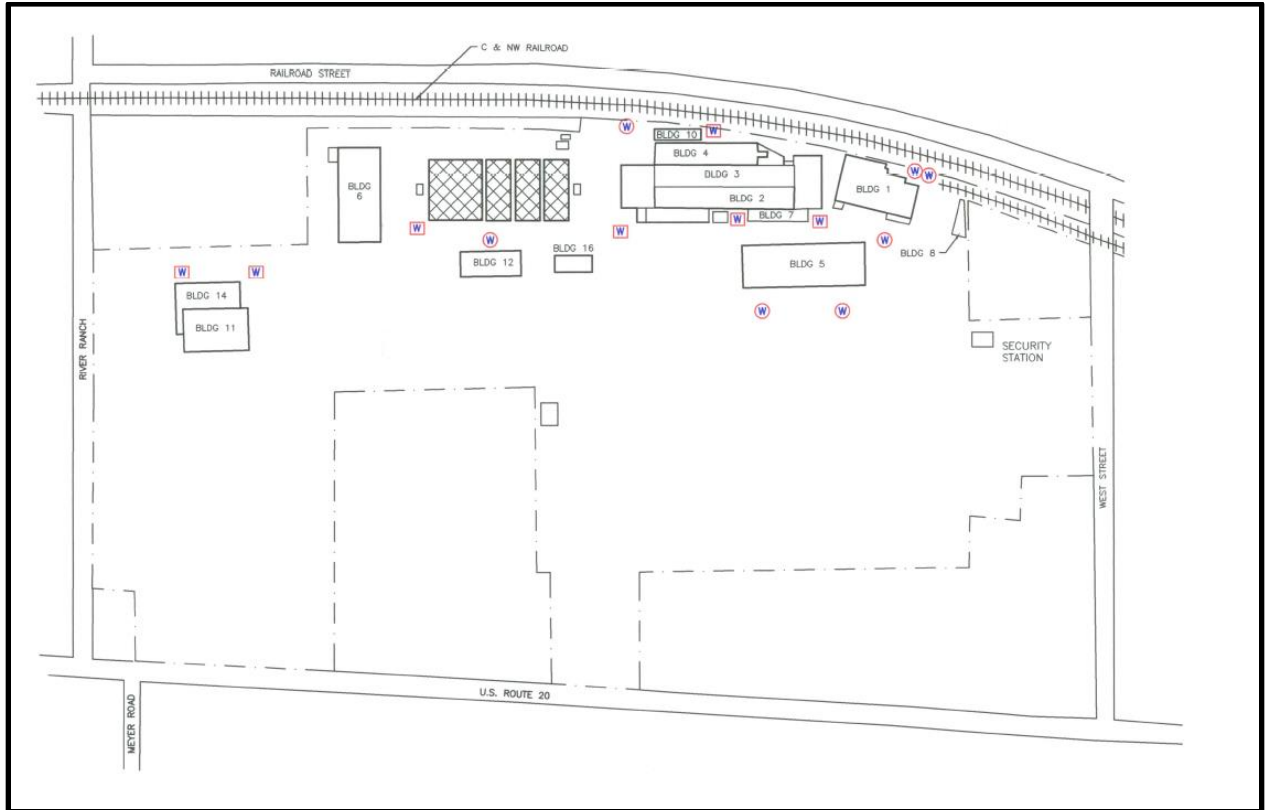


Figure 1. Weston Map of Arnold Site and Numbered Buildings in 1994

Figure 2 shows the Arnold site on the United States Geologic Survey topographic quadrangle map. The site land surface elevation varies between 820 to 805 feet above mean sea level (AMSL)¹.

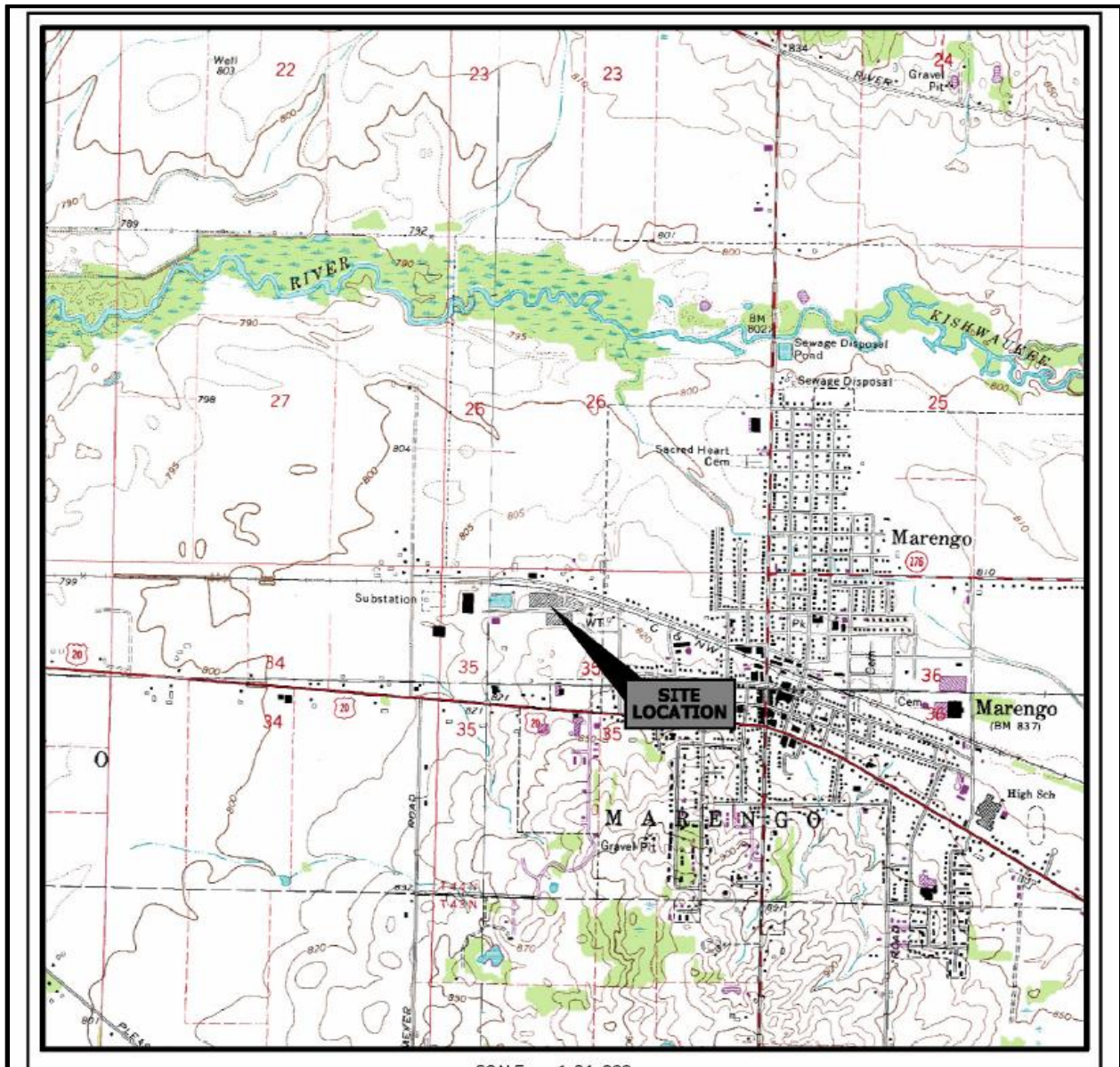


Figure 2. USGS Topographic Map Location of the 300 West Site

¹ "Above mean sea level or AMSL" means the elevation or altitude of any object, relative to the average sea level.

The following is 2015 digital aerial photograph of the 300 West Site and surrounding area from the Illinois State Geological Survey (ISGS) online data base of water and related wells (i.e. blue symbols) in Township (T) 44 North (N), Range (R) 5 East (E), Sections 34, 35, 26 and 27 <http://maps.isgs.illinois.edu/ilwater/>:

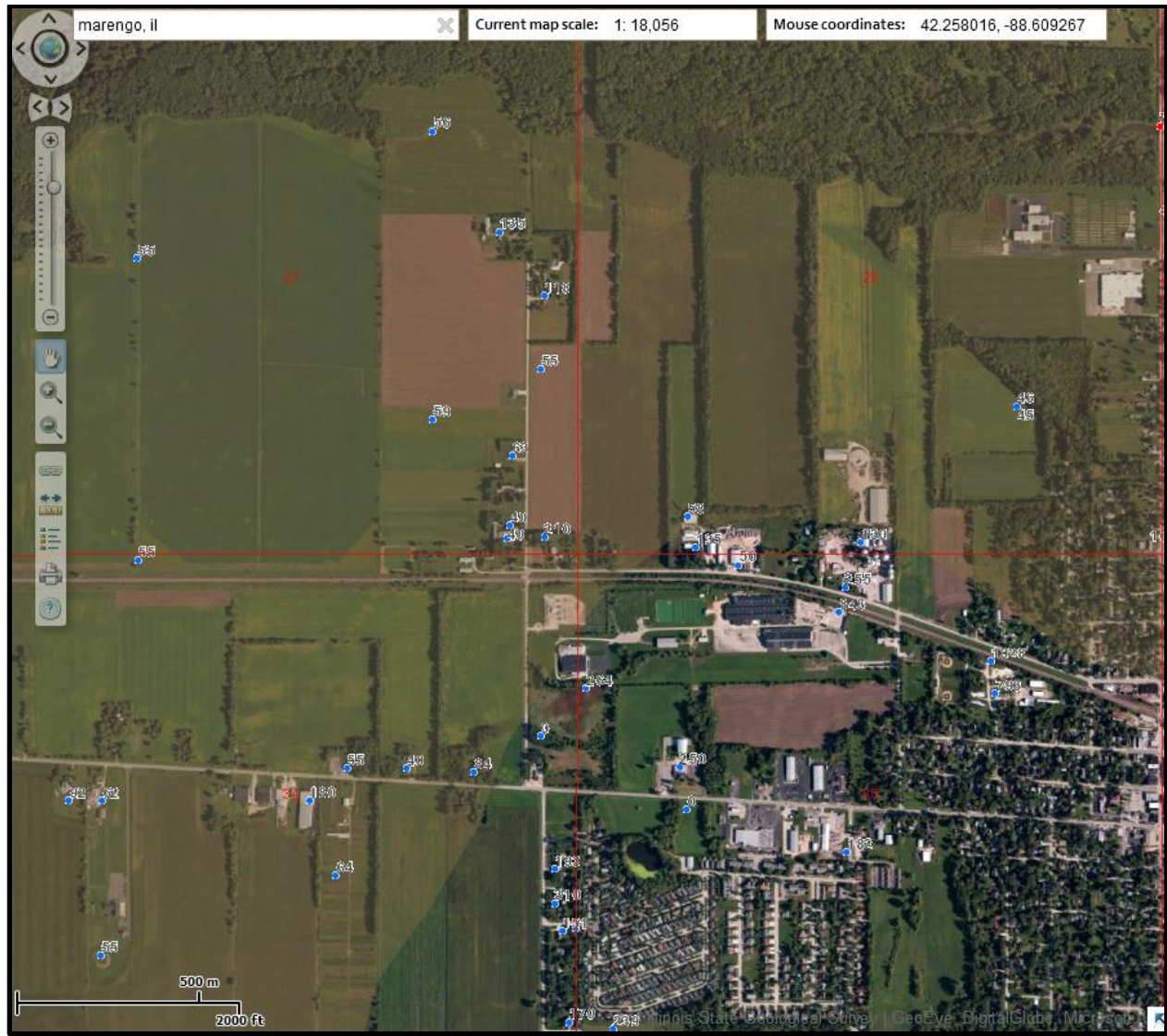


Figure 3. Digital Aerial Photo of 300 West, Water, and Related Wells (ISGS, 2015)

V. Hydrogeologic Principles

Before discussing the hydrogeologic setting at 300 West it is important to define and describe some basic hydrogeologic background concepts and processes.

Water infiltrating the soil may evaporate or be used by plants and be transpired. The remainder of the water migrates downward (percolates) through pore spaces in soil or rock, eventually reaching a zone where all pore spaces are saturated. The top of this zone is the **water table** (Freeze and Cherry, 1979) (See Figure 4). The saturated zone is **groundwater**. "Groundwater" means underground water which occurs within the saturated zone and geologic materials where the fluid pressure in the pore space is equal to or greater than atmospheric pressure. [415 ILCS 5/3.210]

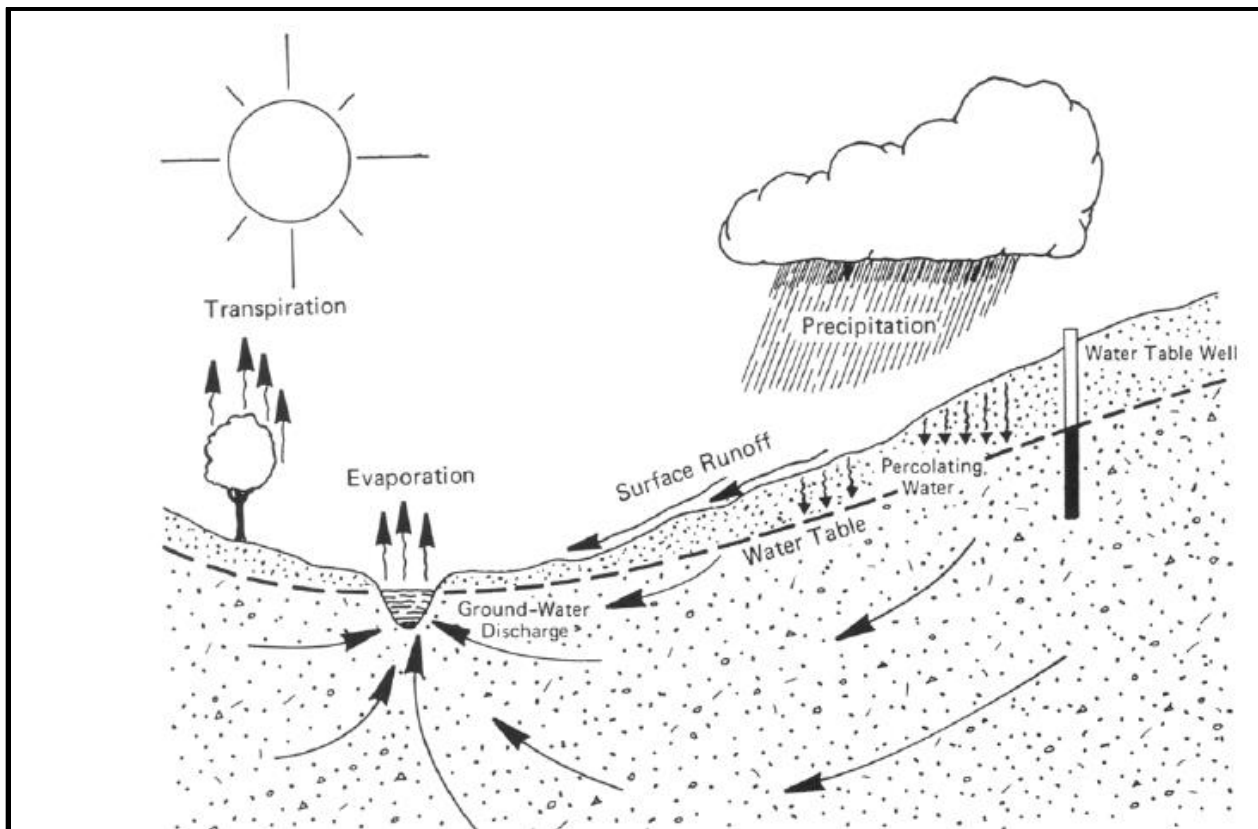


Figure 4. Hydrologic Cycle (Cobb, Wehrmann, and Berg, 1995)

Water that moves into the saturated zone and flows downward, away from the water table is **recharge** (Walton, 1965). Generally, only a portion of recharge will reach an **aquifer**. "Aquifer" means saturated (with groundwater) soils and geologic materials which are sufficiently permeable to readily yield economically useful quantities of water to wells, springs, or streams under ordinary hydraulic gradients. [415 ILCS 55/3(b)] In contrast, an **aquitard** is a bed of low permeability along an aquifer.

The overall recharge rate is affected by several factors, including intensity and amount of precipitation, surface evaporation, vegetative cover, plant water demand, land use, soil moisture content, depth and shape of the water table, distance and direction to a

stream or river, and hydraulic conductivity of soil and geologic materials (Walton, 1965). “**Hydraulic conductivity (K)**” means a hydraulic property expressing the capacity of an earth material to transmit groundwater, or **permeability** (Fetter, 2001). Table 1 quantifies the ability of saturated geologic materials to transmit water (or its permeability) in relation to unit of measurement in feet per day (ft/d). Bear 1972, describes it by a Representative Elemental Volume (REV) of water that will move in a unit time under a unit **head**² gradient through a unit area measured at right angles to the direction of flow in a porous geologic media.

Table 1. Representative Values of Hydraulic Conductivity for Various Rock Types (after Domenico and Schwartz, 1980)

Material	Hydraulic Conductivity in Feet per Day (ft/d)
<i>Unconsolidated rocks</i>	
Gravel	$1 \times 10^2 - 1 \times 10^4$
Coarse sand	$2 \times 10^{-1} - 2 \times 10^{-3}$
Medium sand	$2 \times 10^{-1} - 1 \times 10^{-2}$
Fine sand	$6 \times 10^{-2} - 6 \times 10^{-1}$
Silt, loess	$3 \times 10^{-4} - 6 \times 10^{-0}$
Diamicton (till)	$3 \times 10^{-7} - 6 \times 10^{-1}$
Clay	$3 \times 10^{-6} - 1 \times 10^{-3}$
<i>Sedimentary rocks</i>	
Limestone, dolomite	$3 \times 10^{-6} - 2 \times 10^0$
Sandstone	$1 \times 10^{-4} - 2 \times 10^0$
Shale	$3 \times 10^{-8} - 6 \times 10^{-4}$

(Note: Scientific notation (i.e. 10^{-2} = 0.01 ft/d) is used here to represent small numbers.)

² “**Head**” means the sum of the elevation and the pressure head at a given point in an aquifer.

The 300 West's property is located north of the Marengo Ridge Aquitard (i.e. gray area south of 300 West) on top of the surficial Haeger-Beverly Aquifer (See Figure 5) (Modified after Thomason et al., 2013). The subsurface toe of the ridge bisects the east side of the 300 West Site. The contours on the map below represent the thickness of the surficial sand and gravel aquifer. In McHenry County, the Surficial Aquifer is composed of the shallowest sand and gravel deposits associated with ancient glacial meltwater streams. This aquifer is highly utilized for domestic and municipal water supplies, because it is easily accessible (shallow and often exposed at land surface) and relatively thick (often greater than 50 feet thick). Because of its location near land surface, the aquifer is a major route for deeper groundwater recharge, but it is also often highly sensitive to contamination (Thomason et al., 2013).

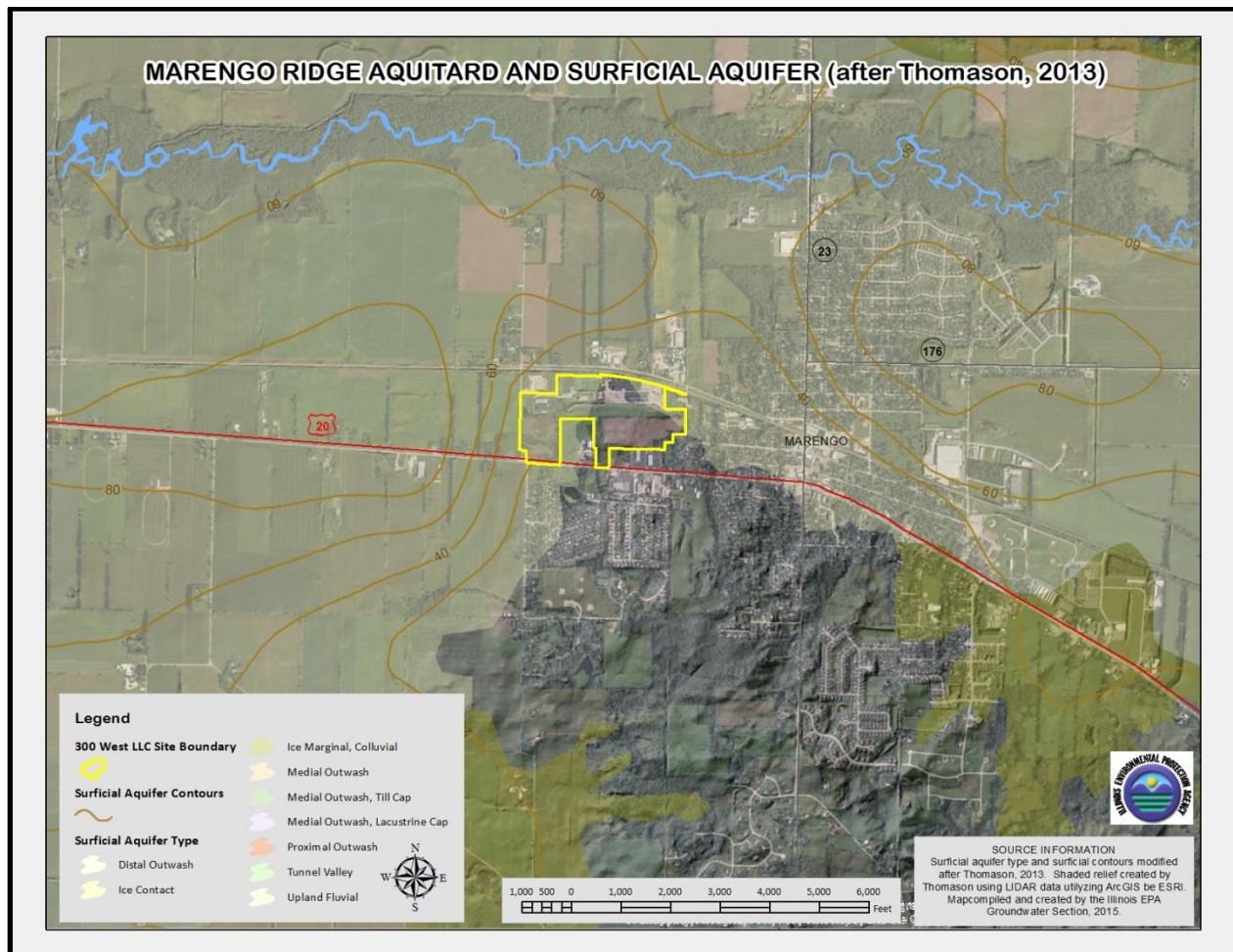


Figure 5. Marengo Ridge Aquitard and Surficial Aquifer Thickness in Relation to 300 West (Modified after Thomason et al., 2013)

The regional thickness of this aquifer underlying 300 West is illustrated in T 44 N, R 5 E, Section 35 of the following map (See Figure 6). The dark gray area on the map below is the Marengo Ridge that is comprised of fine grained low permeability glacial **till**.³

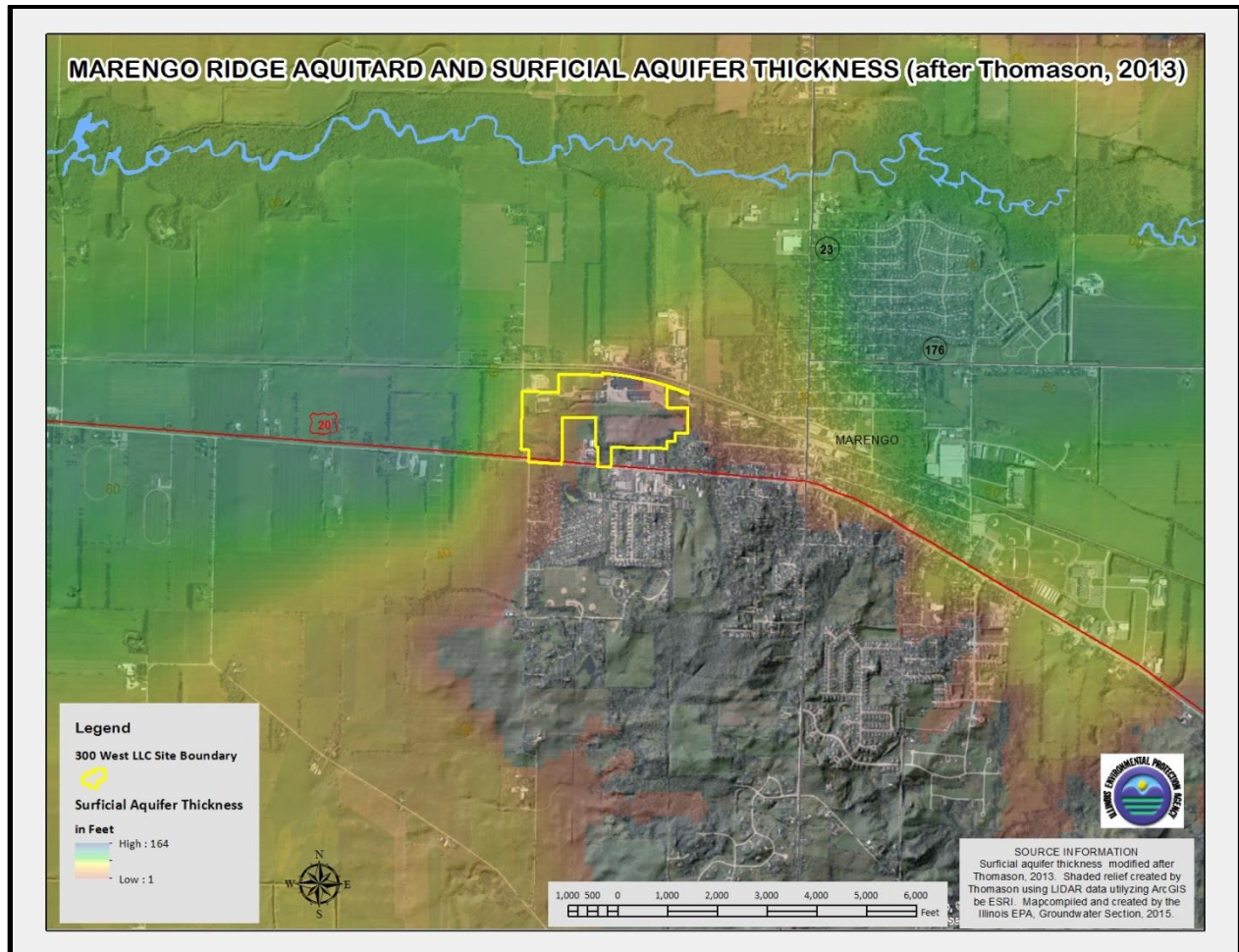


Figure 6. Thickness of the Haeger-Beverly Aquifer in Relation to 300 West (Modified after Thomason et al., 2013)

This aquifer has a very high potential for contamination due to the alluvial deposits of fine-medium sand with some gravelly beds at the surface (See Figure 7). EGSL's Right-to-Know Response Report (EGSL, January 13, 2013) indicated a very high hydraulic conductivity of 1.73×10^{-3} feet per second or 5.2×10^{-2} centimeters per second. This equals 1.49×10^2 ft/d to compare with the units used in Table 1. Note the geologic susceptibility symbols used in the map below relate to the depth to the top of the aquifer and the thickness of the aquifer. The map symbol A1 means that the aquifer is greater

³ "**Till or glacial till**" means unsorted glacial sediment. Glacial till is that part of glacial drift which was deposited directly by the glacier. Its content may vary from clays to mixtures of clay, sand, gravel and boulders.

than 50 feet thick and is located within 5 feet of land surface. Further, A2 means that the aquifer is greater than 50 feet thick and is located between 5 and 20 feet below land surface.

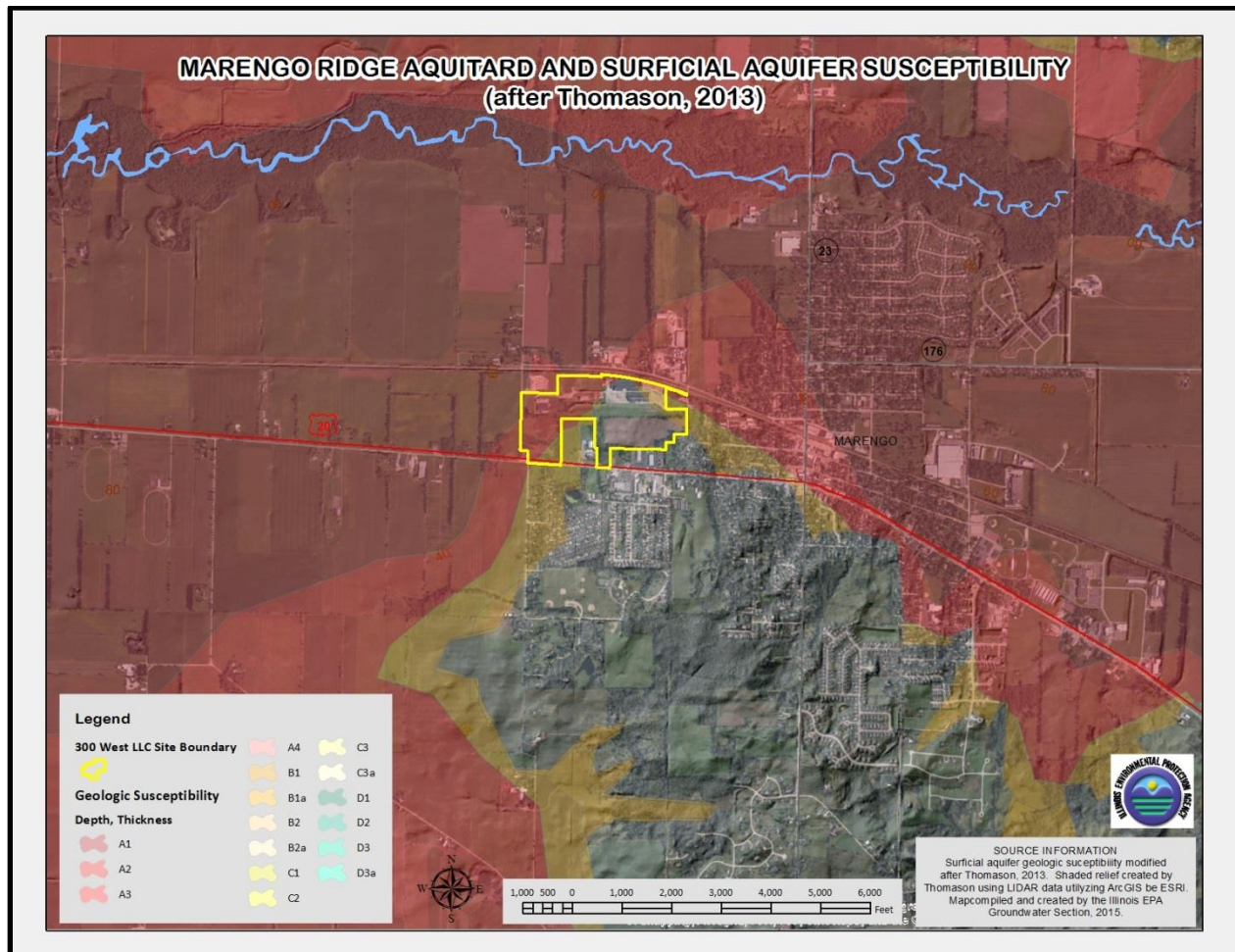


Figure 7. Geologic Susceptibility of the Surficial Aquifer in Relation to 300 West (Modified after Thomason et al., 2013)

The top of the water table has been shown to vary from 4 to 15 feet below ground surface (bgs) in the Haeger-Beverly Aquifer under the 300 West Site (Roux, 1990) (PRC, 1993) (Fehr-Graham, 2001) (EGSL, 2006, 2010, 2013, 2015). Meyer et al., 2013 shows geologic cross sections for the Haeger-Beverly Aquifer in proximity to the village of Marengo and the Marengo Ridge (See Figure 8). 300 West sits right at the interface between the ridge and the aquifer.

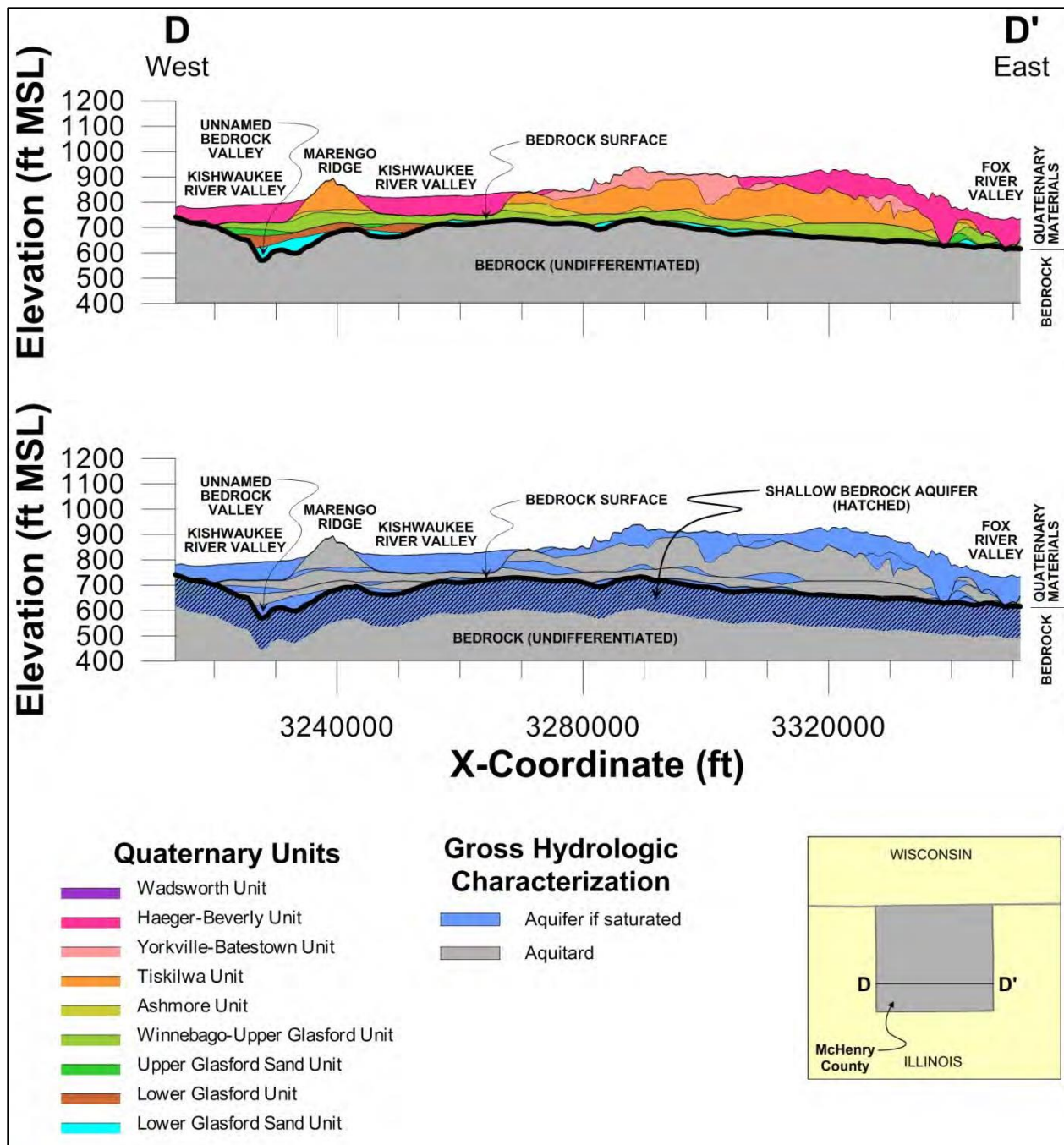


Figure 8. Geologic Cross Section and Gross Hydrologic Characterization of the Haeger-Beverly Aquifer and the Marengo Ridge Aquitard near Marengo (Meyer et al., 2013)

The ISGS has also developed a 3-dimensional (3-D) model of the geology in McHenry County as shown in Figure 9 (Thomason et al., 2013) <https://www.isgs.illinois.edu/three-dimensional-3-d-geologic-modeling-mchenry-county-illinois>.

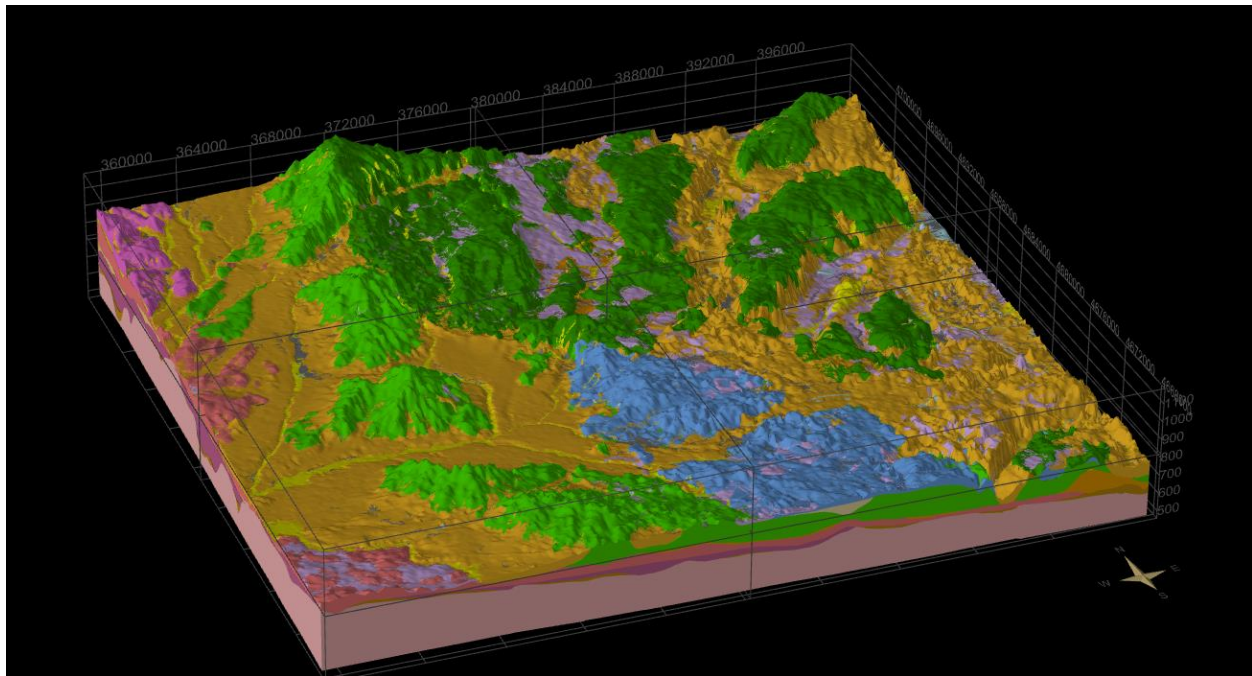


Figure 9. ISGS 3-D Geologic Model of McHenry County

Geologic cross sections can be drawn anywhere using this 3-D model of the geology. The following is a screen shot of the Subsurface Viewer (Insight® Subsurface Viewer, 2009) cross section through Margeno Ridge and 300 West (See Figure 10). Figure 11 is the cross section developed using the ISGS model and the Subsurface Viewer.

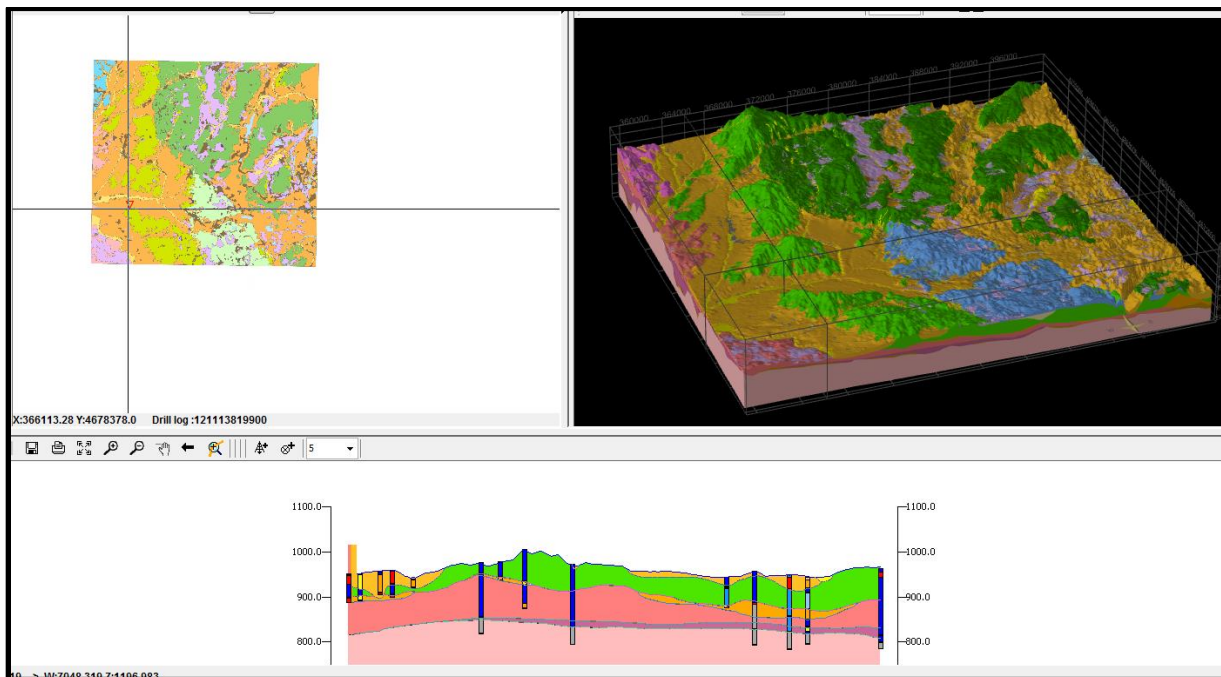


Figure 10. Subsurface Viewer Screen Shot

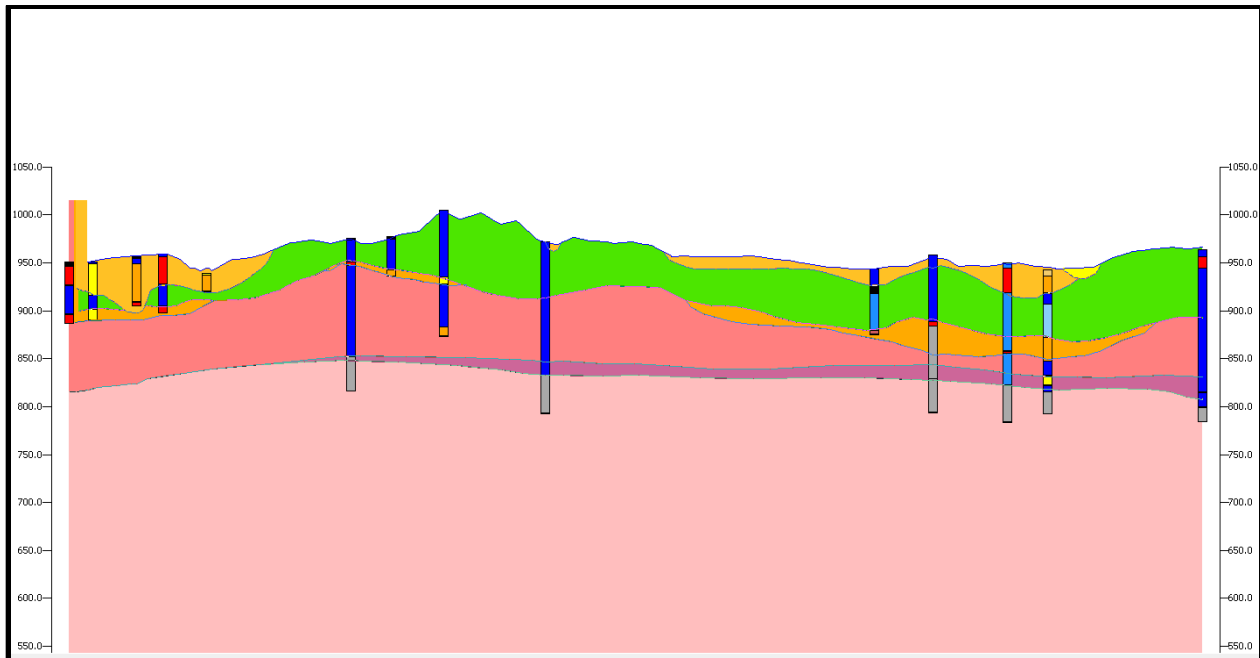


Figure 11. Geologic Cross Section through Marengo Ridge and 300 West

The colors in the Figure 11 geologic cross section represent the following:

- Yellow – sand and gravel;
- Green – till; and
- Pink – shallow bedrock.

VI. Groundwater Flow

The water table can be determined by measuring the elevation of water surfaces in wells that penetrate the saturated zone. Under natural conditions, the water table forms a surface that resembles the overlying land surface topography (See Figure 2), only in a more subdued and smoother configuration. The water table generally will be at higher elevations (up gradient) beneath upland areas and at lower elevations in valley bottoms (down gradient). The water table may intersect the ground surface along perennial streams, springs, and lakes, which are natural areas of groundwater discharge (See Figure 4). Groundwater moves in a fashion somewhat analogous to surface water, only at much slower rates (See Table 1). While surface water moves downhill in response to gravity, groundwater moves down-gradient from areas of higher potential energy⁴ to areas of lower potential energy. These points in an aquifer are described as **hydraulic head** (Fetter, 2001). Groundwater flows from recharge zones, where infiltration occurs, to discharge zones, where groundwater discharges into streams, lakes, and wells. Generally, **groundwater flow will be perpendicular to the contours** (i.e. areas of equal elevation or **equipotential**) of the **potentiometric surface**⁵ (Fetter, 2001).

⁴ “**Potential energy**” is the energy that an object has due to its position in a force field (i.e. gravitational field).

⁵ “**Potentiometric surface**” A *potentiometric surface map* is a contour map of the potentiometric, or pressure, surface of a particular hydrogeologic unit (Fetter, 2001) that illustrates hydraulic head, or the

Meyer et al., 2013, includes the regional potentiometric surface for the Haeger-Beverly Aquifer north of Marengo Ridge where 300 West is located (See Figure 12). Down gradient of the 300 West site the regional water table is at an elevation of 790' above AMSL, and down gradient of that the Kishwaukee River is at an elevation of 780' AMSL.

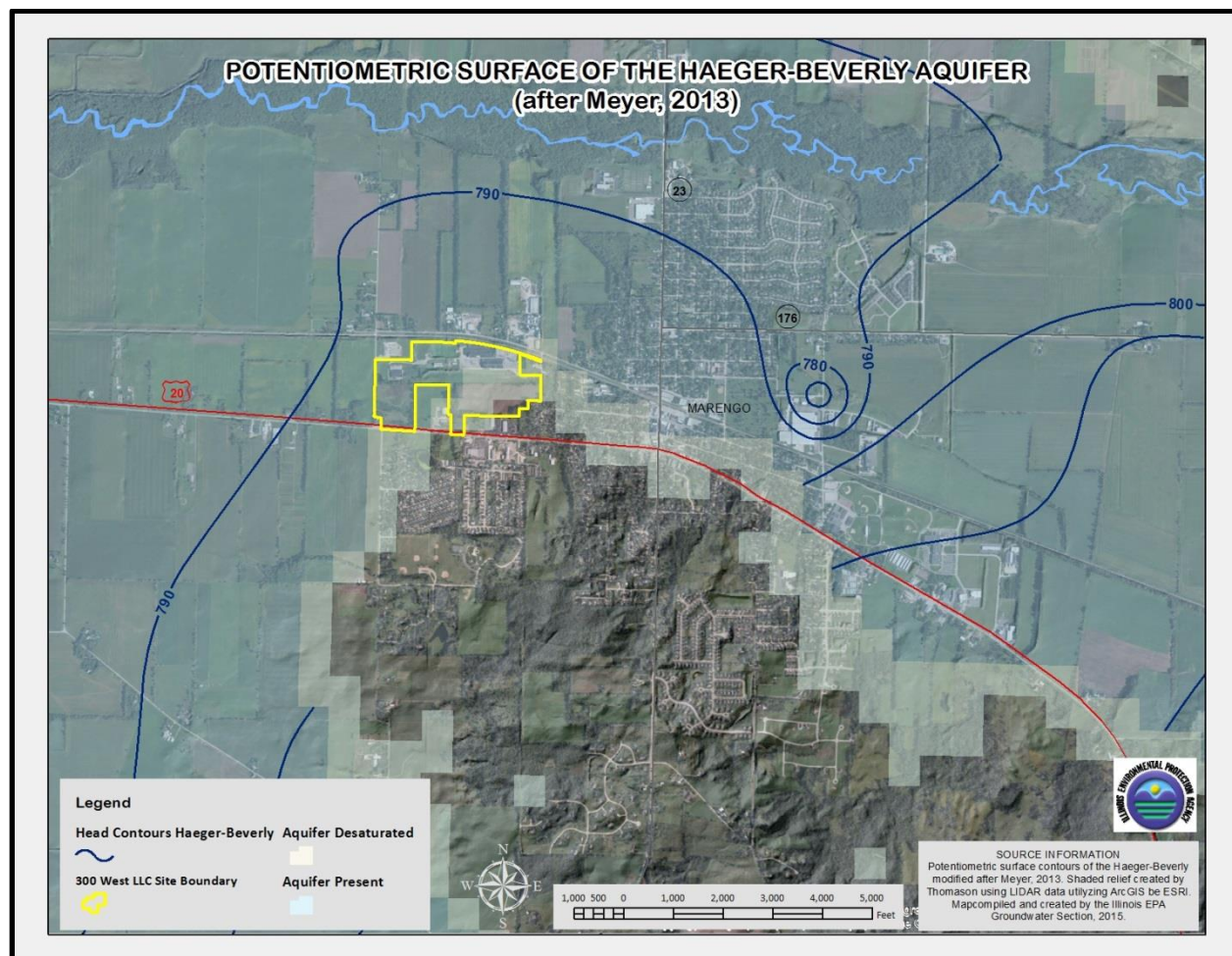


Figure 12. Regional Potentiometric Surface of the Haeger-Beverly Aquifer (Modified After Meyer et al., 2013)

Roux and Associates installed three groundwater monitoring wells (MW): MW-1 (27' bgs); MW-2 (23' bgs); and MW-3 (22' bgs) on-site in February 1990 to develop the following potentiometric surface maps and groundwater flow directions (See Figures 13

level to which water will rise, in tightly cased wells in that hydrogeologic unit. A potentiometric surface map is analogous to a topographic map of the land surface, but rather than the land surface, it depicts the surface defined by water levels in wells. These maps can be constructed for both confined and unconfined aquifers and are sometimes referred to as water level maps or head maps. A potentiometric surface map of an unconfined aquifer is essentially a map of the water table; a potentiometric surface map of a confined aquifer is a map of an imaginary pressure surface. Both are based on the elevation to which water levels rise in wells completed in the aquifer of interest. *Contour lines or equipotentials* connect points of equal head and represent head values. Groundwater flows from high head to low head, and directions of groundwater flow are perpendicular to equipotentials. A head map can be used to determine groundwater flow directions as well as variations in head distribution.

and 14). It should be noted that the flow direction shifted from northwest to north in Figure 11 after an extensive rainfall (Roux, 1990). Data reviewed from the Midwestern Regional Climate Center station in Marengo (<http://mrcc.isws.illinois.edu/>) confirms that that there was almost 3 inches of rainfall between March 9 and 15, 1990. The potentiometric surface maps developed by Roux shows that the groundwater head elevation in MW 3 varied between 792' and 793' AMSL.



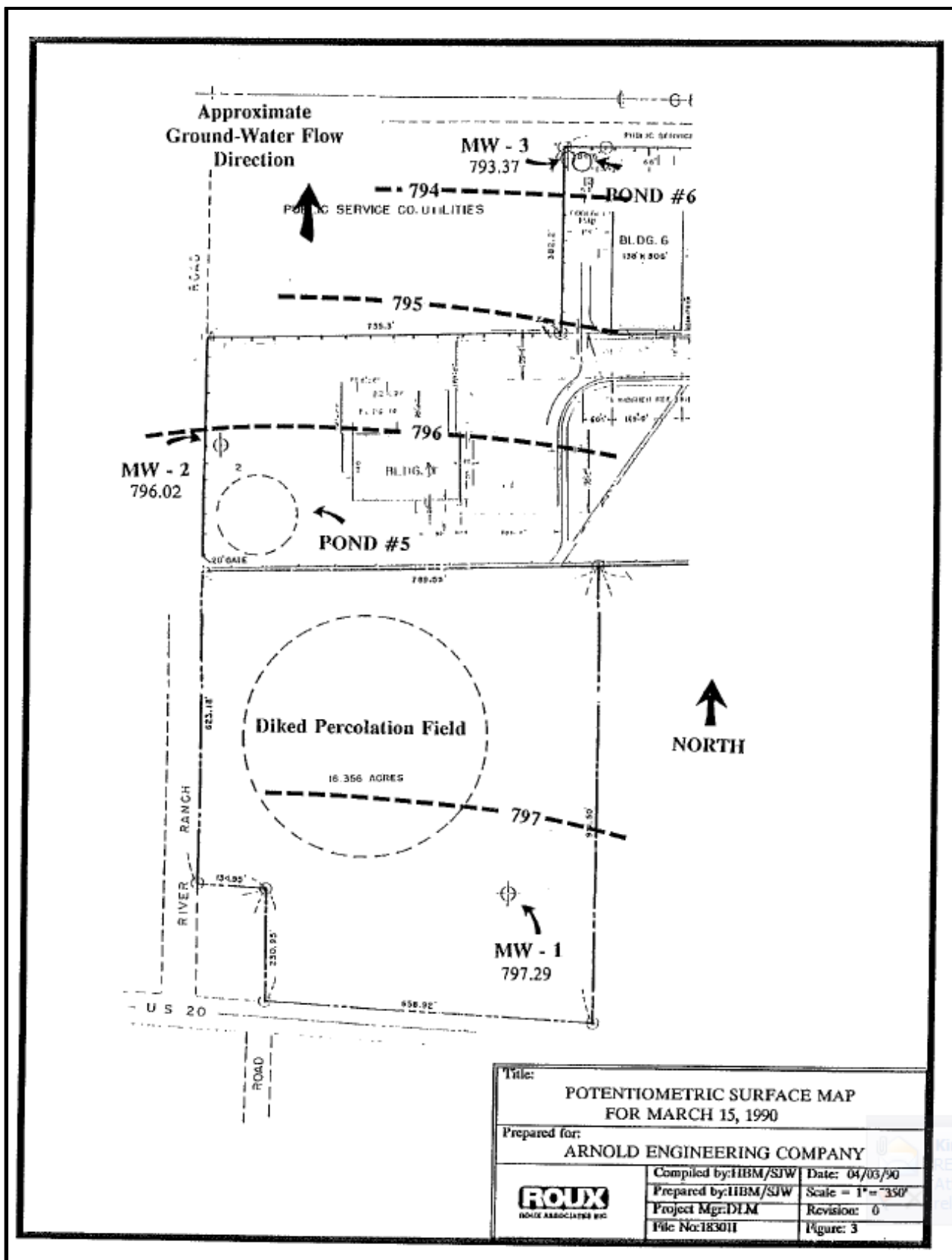


Figure 14. Map of On-Site Potentiometric Surface and Groundwater Flow Direction March 15, 1990

MW 1 is an up gradient well that is used to determine the direction of groundwater flow, but is also used to determine background groundwater quality coming onto the site.

In 2001, Fehr-Graham installed 5 additional MWs (MW - A4, A5, A6, A7 and A8) and 7 piezometers to develop the following updated potentiometric surface and groundwater flow direction map (See Figure 15). Piezometers are only used to measure water levels. These MWs and piezometers were installed at the request of Illinois EPA with the intent of determining the source of groundwater contamination in MW3. The elevation of the groundwater on the Fehr-Graham potentiometric surface varied from 814' to 793' AMSL. MW 3 is down gradient with a water level elevation of 793.6' AMSL. The 800' contour appears to be the boundary between the aquifer and the low permeability upland glacial till of the Marengo Ridge Aquitard.

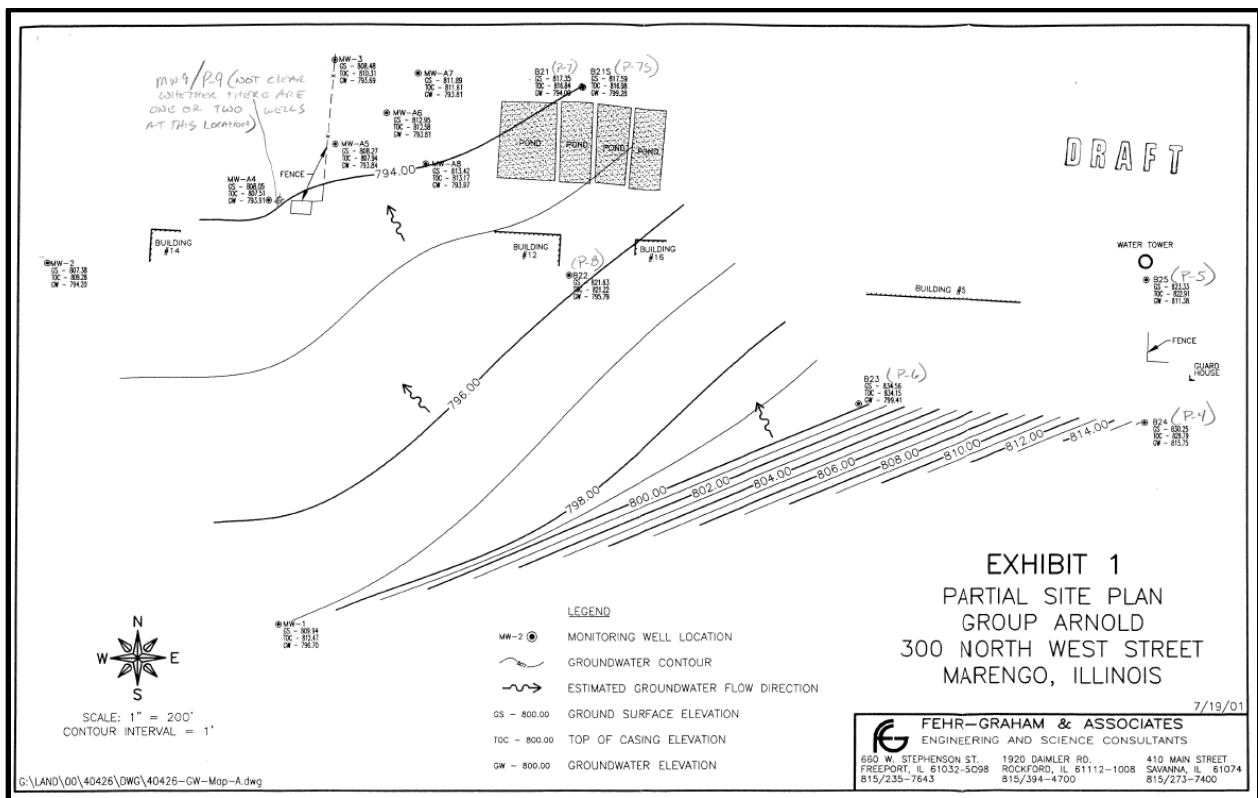


Figure 15. Updated Map of On-Site Potentiometric Surface and Groundwater Flow Direction July 19, 2001

VII. Zone of Capture

The seasonal use of the 'McHenry County Conservation District (MCCD) irrigation wells (See Appendix II) are producing capture zones that are influencing the movement of the contaminant plumes from 300 West. Thus, it is necessary to describe the effects of pumping on the natural groundwater flow system. The withdrawal of groundwater by a well causes a lowering of water levels in the water table around the well. The difference between water levels during non-pumping and pumping conditions is called **drawdown** (Fetter, 2001) (See Figure 16). From a three-dimensional perspective, the pattern of drawdown around a single pumping well resembles a cone, with the greatest drawdown adjacent to the pumping well. The water table drawdown area affected by the pumping well, therefore, is called the **cone of depression** (Fetter, 2001). For example, see the cone of depression produced by the village of Marengo's community water supply wells east of the word Marengo on the Figure 12 map of the regional potentiometric surface.

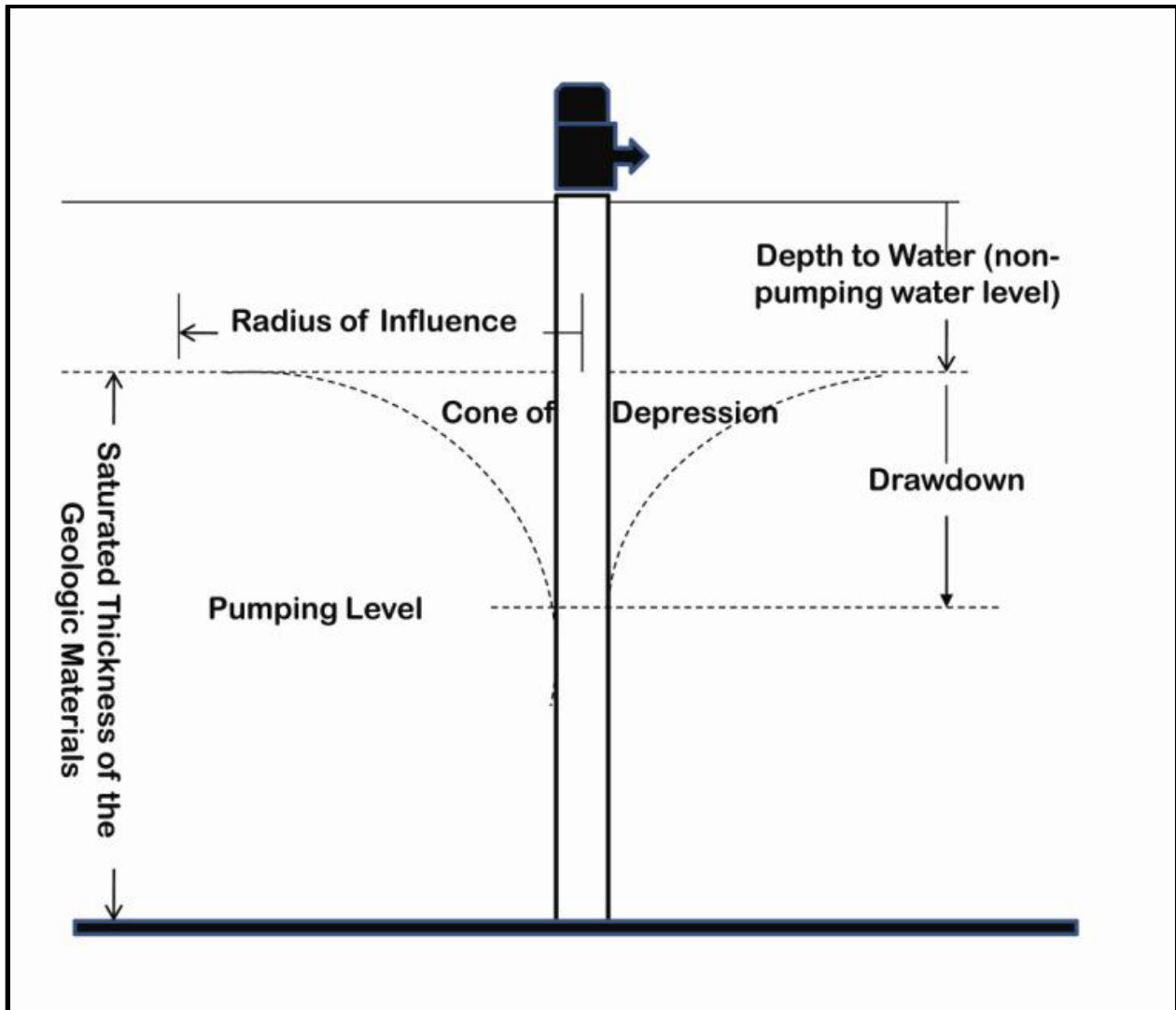


Figure 16. Illustration of the Cone of Depression Created by a Pumping Well (Cobb, 2009)

The cone of depression's rim delineates the outside edge of the well's **lateral area of influence** (LAI). Further, the radius of the LAI is referred to as the radius of influence. The three-dimensional region of groundwater entering the well's LAI boundary is referred to as the **zone of capture** (ZOC) (See Figure 17) (Todd, 1980). The ZOC is the entire three-dimensional region from which groundwater is eventually pulled into a pumping well.

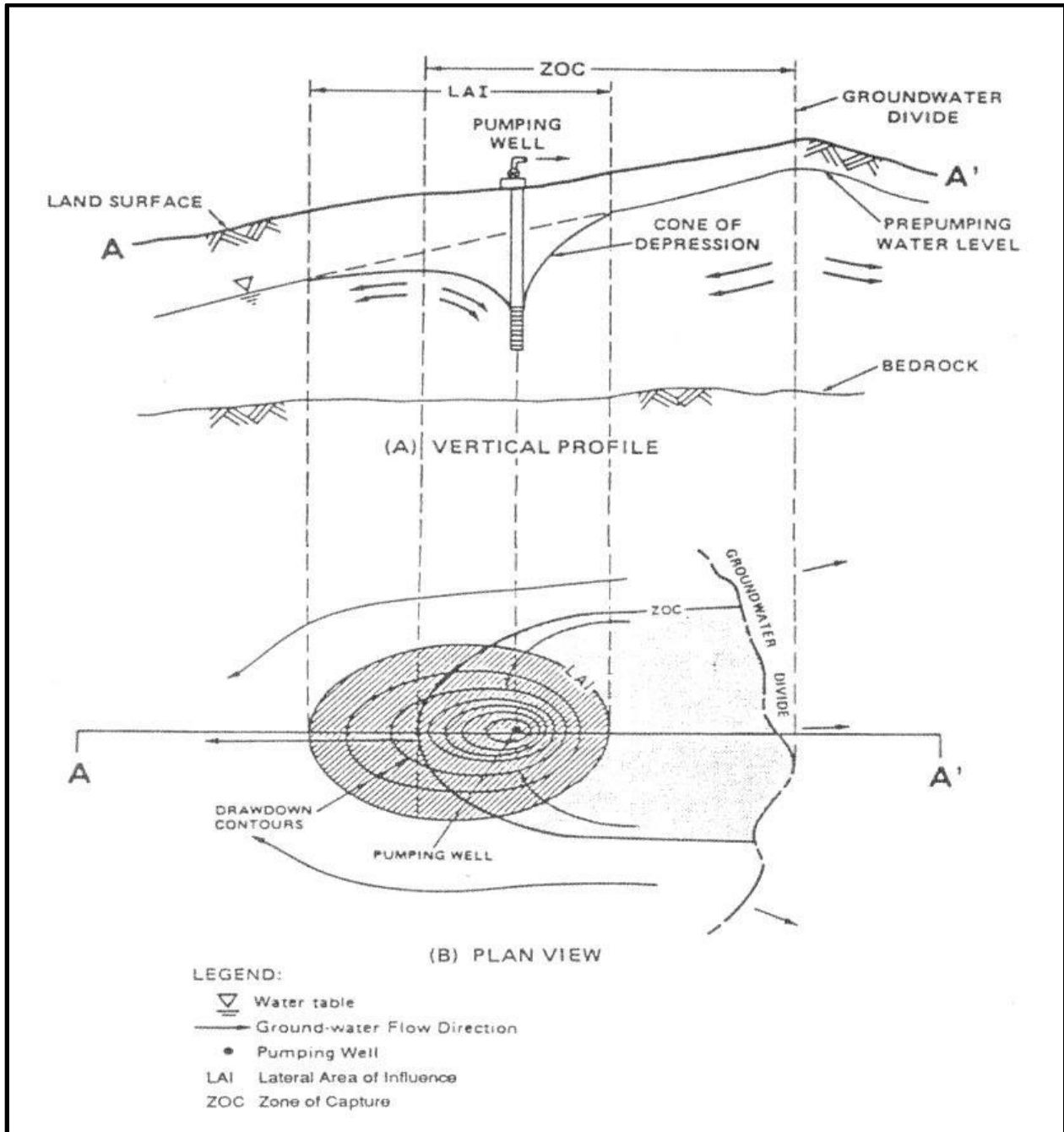


Figure 17. Illustration of the ZOC Produced by a Pumping Well (Cobb, 2009)

The Illinois State Water Survey has developed a groundwater flow model for McHenry County (Meyer et al., 2013). This model was used to predict the effect of pumping stress from the 55 foot deep MCCD IR wells on groundwater flow. The geologic well logs for these wells are included in Appendix II. The ZOC's of these irrigation wells were simulated (Anderson, 1992) based on the following information:

- Estimated the withdrawals as 1 inch of water applied to the field per week for a growing season of 18 weeks;
- Irrigated area of the field is 7,000,000 square feet (ft²), as estimated from Google Earth;
- Total withdrawals are estimated as 224,400 gallons per day (GPD) between the two wells; each well was assumed to pump half of this value (112,200 GPD).

Figure 18 shows the ZOCs simulated at a rate of 224,400 GPD (155 gallons per minute (gpm)) and figure 19 shows the predicted ZOCs at half that rate:

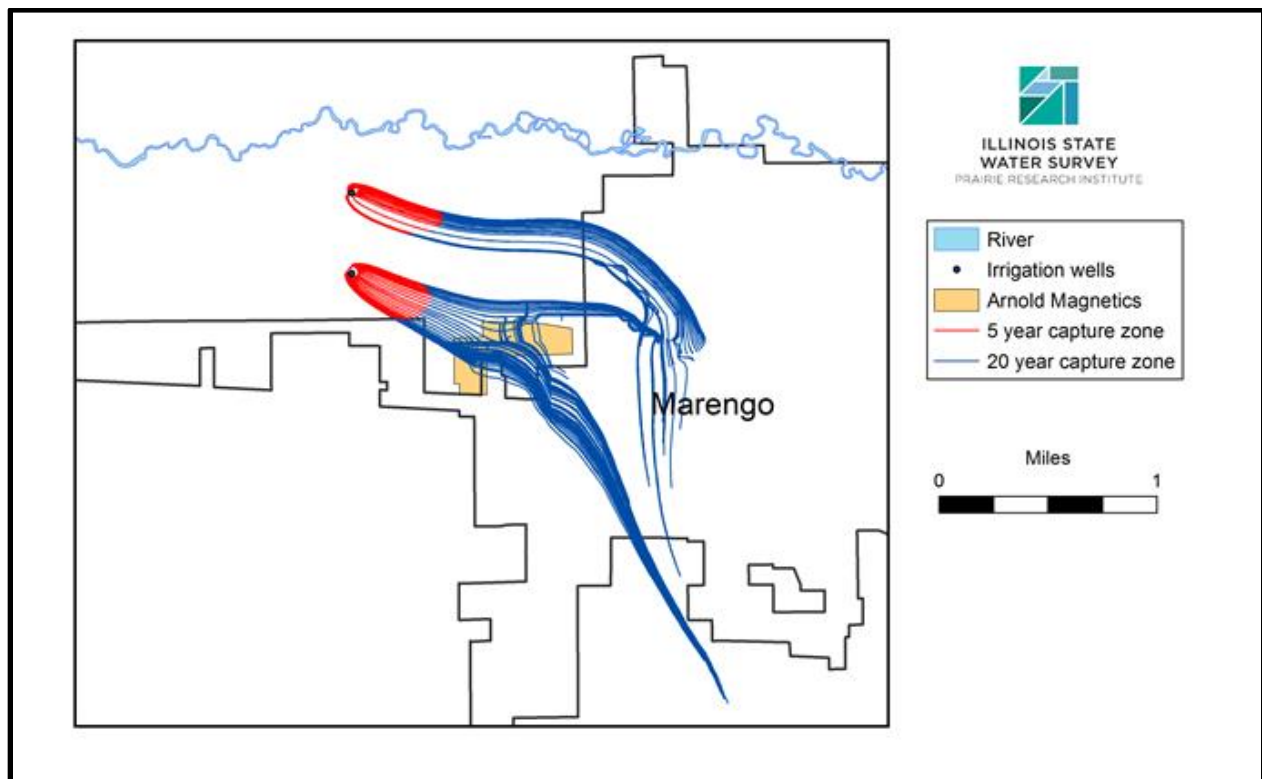


Figure 18. Modeled ZOCs for the MCCD IR Wells at 224,400 GPD

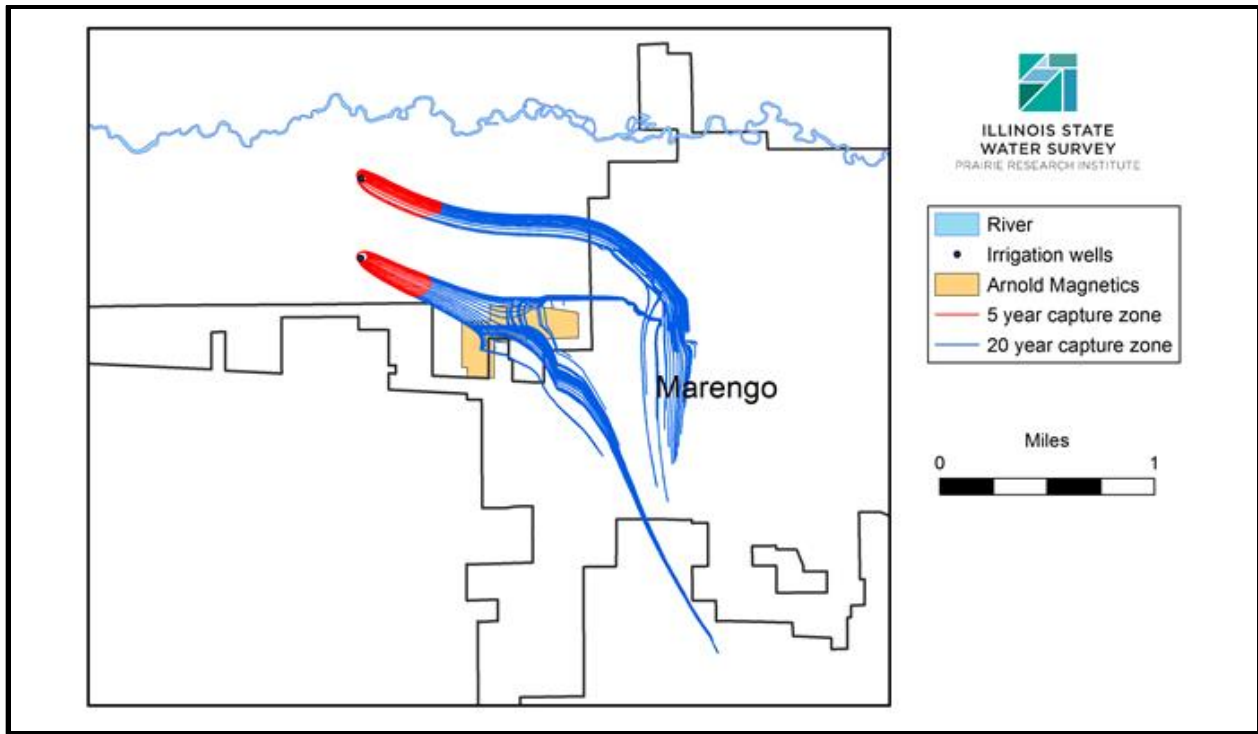


Figure 19. Modeled ZOCs for the MCCD IR Wells at 112,200 GPD

VIII. Contaminant Fate and Transport

In general, contaminants are transported in the direction of groundwater flow. Transport in this manner, that is, transport of dissolved constituents (solutes) at the same speed as the average groundwater pore velocity, is called **advection** (Fetter, 2001). In porous natural materials the pores possess different sizes, shapes, and orientations. Similar to stream flow, a velocity distribution exists within the pore spaces such that the rate of movement is greater in the center of the pore than at the edges. Thus, in saturated flow through these materials, velocities vary widely across any single pore and between pores (See Figure 20).

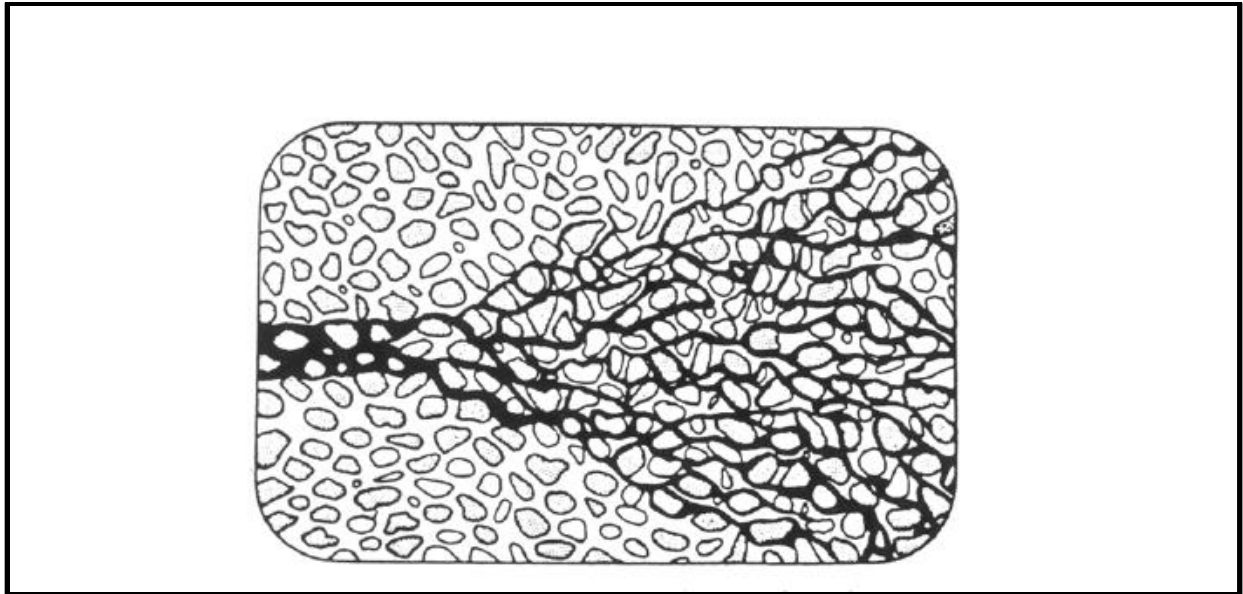


Figure 20. Flow Distortion on a Microscopic Scale (Freeze and Cherry, 1979)

As a result, when a ***miscible***⁶ fluid is introduced into a flow system it will mix mechanically and ***diffuse*** (because of tightly packed molecules bumping into one another) to occupy an ever increasing portion of the flow field (Fetter, 2001). The fate and transport of VOCs and 1,4 D are governed in part by their physio-chemical properties. The solvents used at 300 West are slightly miscible or soluble because they dissolve in groundwater. Solubility is a measure of how much a contaminant will dissolve in water (See Table 2). Table 2 shows the relative solubility's between VOCs and 1,4 D. It is important to note that the 111 TCA stabilizer and corrosion inhibitor, 1,4 D is considered to be totally miscible in water and is 10,000 times more soluble than 111 TCA (Mohr, 2010).

The mixing phenomenon of contaminants in groundwater is known as ***hydrodynamic dispersion*** (Domenico and Schwartz, 1998). In this sense, dispersion is a mechanism of ***dilution***. Dispersion acts to reduce the peak concentration of material introduced into a flow field (Fetter, 2001). Contaminant plumes can result from a continuous (A) or from one time source of contamination (B), as shown in Figure 21. Horizontal versus transverse dispersion results in plume widths that are typically an order of magnitude less than plume length (Fetter, 1993 and Gelhar et al., 1992), as conceptually illustrated below (See Figure 21).

⁶ ***"Miscible"*** means capable of being mixed; specifically: capable of mixing in any ratio without separation of two phases.

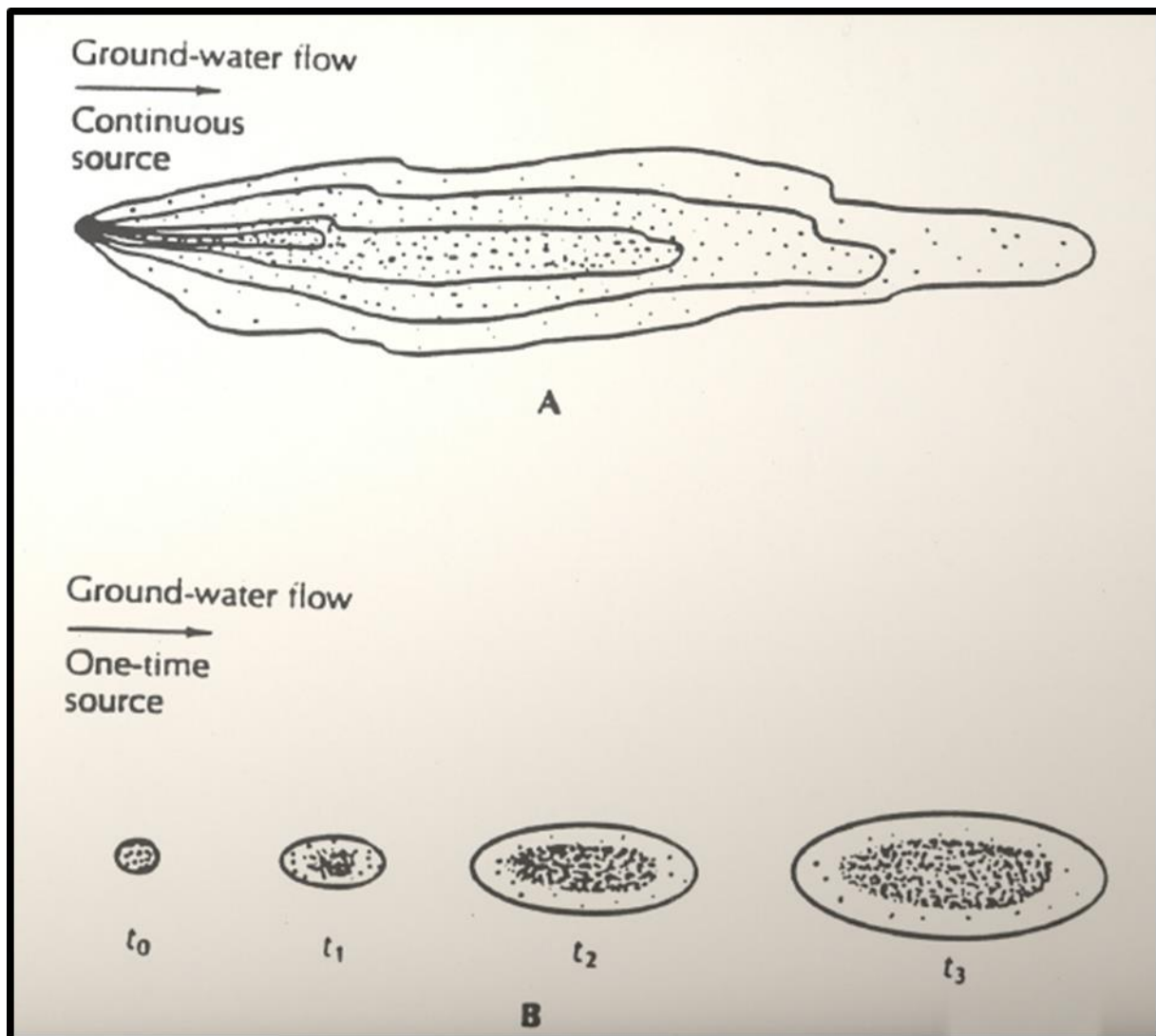


Figure 21. Map View Conceptual Illustration of the Mass Transport of Contaminants from a Continuous Source versus a One Time Source (Modified After Freeze and Cherry, 1979)

The following tables 2 and 3 (Lawrence, 2006 and Mohr, 2001) list the solubility and the density of the VOCs and the associated 1,4 D stabilizer and corrosion inhibitor used at 300 West:

Table 2. VOC and 1,4 D Solubility in Water (Lawrence, 2006 and Mohr, 2001)

International Union of Pure and Applied Chemistry (IUPAC) Name	Common or alternative name	Water solubility milligrams per liter (mg/L at 25°C)
1,4 dioxane		Totally miscible
cis-1,2-dichloroethene	cis-1,2-dichloroethylene	6,400
1,1-dichloroethane	1,1-ethylidene dichloride	5,000
trans-1,2-dichloroethene	trans-1,2-dichloroethylene	4,500
Chloroethene	vinyl chloride, chloroethylene	2,700
1,1-dichloroethene	1,1-dichloroethylene, DCE	2,420
1,1,1-trichloroethane	methyl chloroform	1,290
Tetrachloroethene	perchloroethylene, tetrachloroethylene, PCE	1,210
1,1,2-trichloroethene	1, 1, 2-trichloroethylene, TCE	1,280

Table 3. VOC and 1,4 D Densities Relative to Water (Lawrence, 2006 and Mohr, 2001)

IUPAC name	Common or alternative name	Density in grams per cubic centimeter (g/cm ³ , 20°C)
chloroethene	vinyl chloride, chloroethylene	2.68
Tetrachloroethene	Perchloroethylene, tetrachloroethylene, PCE	1.623
1,1,2-trichloroethene	1,1,2-trichloroethylene, TCE	1.464
1,1,1-trichloroethane	methyl chloroform	1.339
<i>cis</i> -1,2-dichloroethene	<i>cis</i> -1,2-dichloroethylene	1.284
<i>trans</i> -1,2-dichloroethene	<i>trans</i> -1,2-dichloroethylene	1.256
1,1-dichloroethene	1,1-dichloroethylene, DCE	1.213
1,1-dichloroethane	1,1-ethylidene dichloride	1.176
1,4 dioxane		1.03
pure water at 20°C		1.000

Dense non-aqueous phase liquids (DNAPLs) such as the VOCs in Table 2, which are denser than water (1 g/cm³) (See Table 3), are only slightly soluble (or miscible) in water and therefore can also exist in the subsurface as a separate fluid phase immiscible with both water and air (Domenico, 1998) (See Table 2). However, VOC DNAPLs have the ability to migrate to significant depths below the water table where they slowly dissolve into flowing groundwater, giving rise to aqueous phase plumes (Kueper, 2003). Therefore, once the DNAPL solvents that were used at 300 West became dissolved in water they were subject to hydrodynamic dispersion, **hydrolysis**⁷, and degradation. Common types of DNAPLs include the degreasing solvents used at 300 West such as 111 TCA, PCE and TCE. Therefore, as the VOC plume(s) move horizontally down gradient from 300 West they also migrate vertically (Domenico, 1998) (See Figure 22). In comparison, 1,4 D is almost the same density as water.

⁷ "**Hydrolysis**" means the cleavage of chemical bonds by the addition of water.

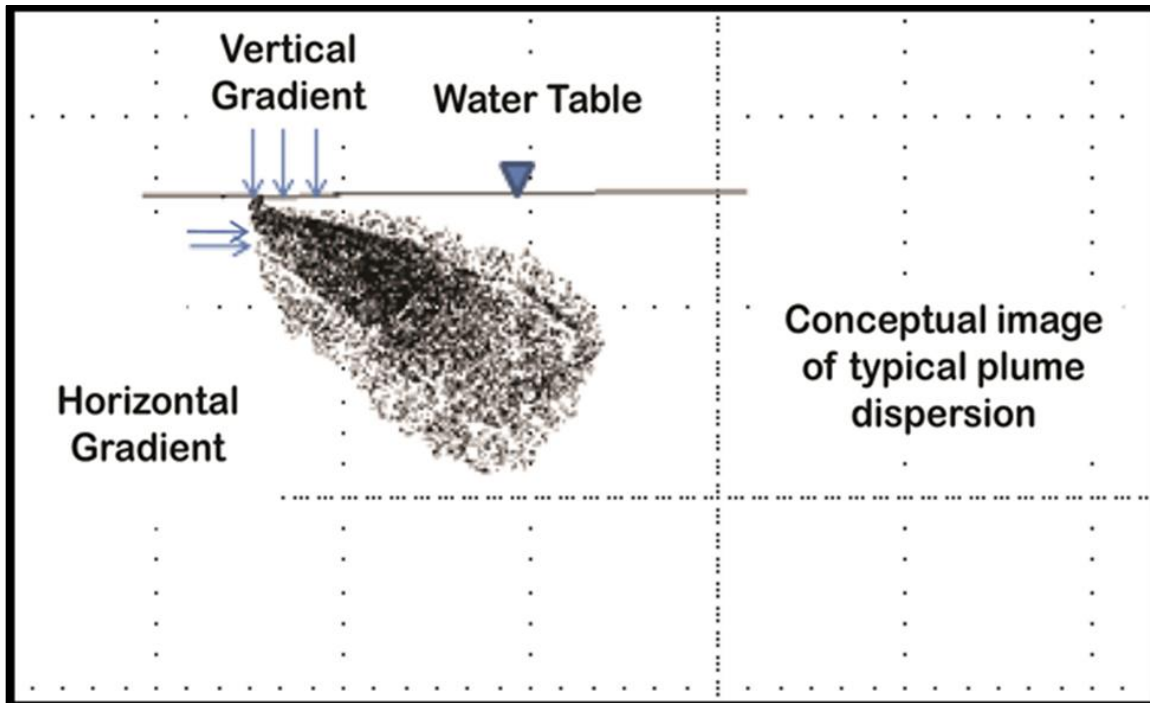


Figure 22. Illustration of DNAPL Plume as it Migrates Horizontally and Vertically Down Gradient in an aquifer (Cobb, 2009)

Further, DNAPLs that migrate down to a low permeability layer (i.e. toe of the Marengo Ridge) will pool. This pool can migrate down the slope of this low permeability layer, as illustrated in Figure 23.

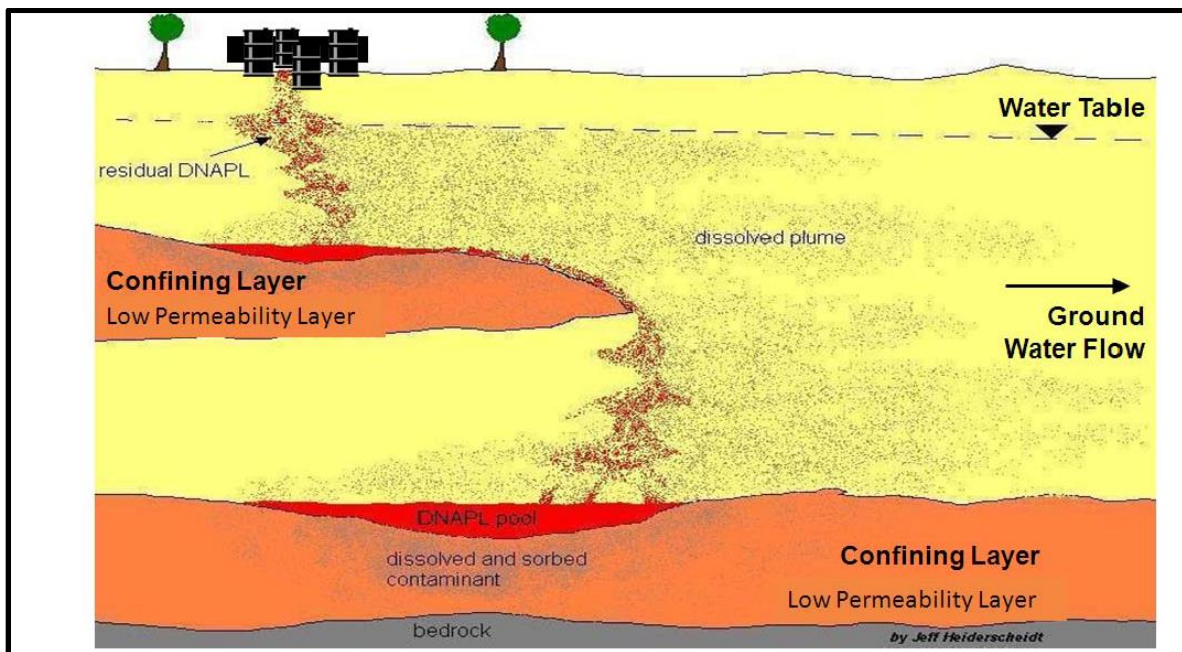


Figure 23. DNAPL Movement in the Subsurface Relative to Low Permeability Geologic Materials (Miniter, 2011)

In addition to dispersion, some VOCs are also subject to **degradation** and **transformation** into different compounds over time. Degradation can occur under aerobic conditions (oxygen rich) or under anaerobic conditions (low oxygen or reducing conditions) (Fetter, 1993). Morrison 2006, shows that the metal degreaser 111 TCA transforms to 1,1 Dichloroethylene (1,1 DCE) by hydrolysis, and 1,1 DCE biodegrades under low oxygen conditions to vinyl chloride (VC). Alternatively, 111 TCA can biodegrade to 1,1 Dichloroethane (1,1 DCA) (See Figure 24).

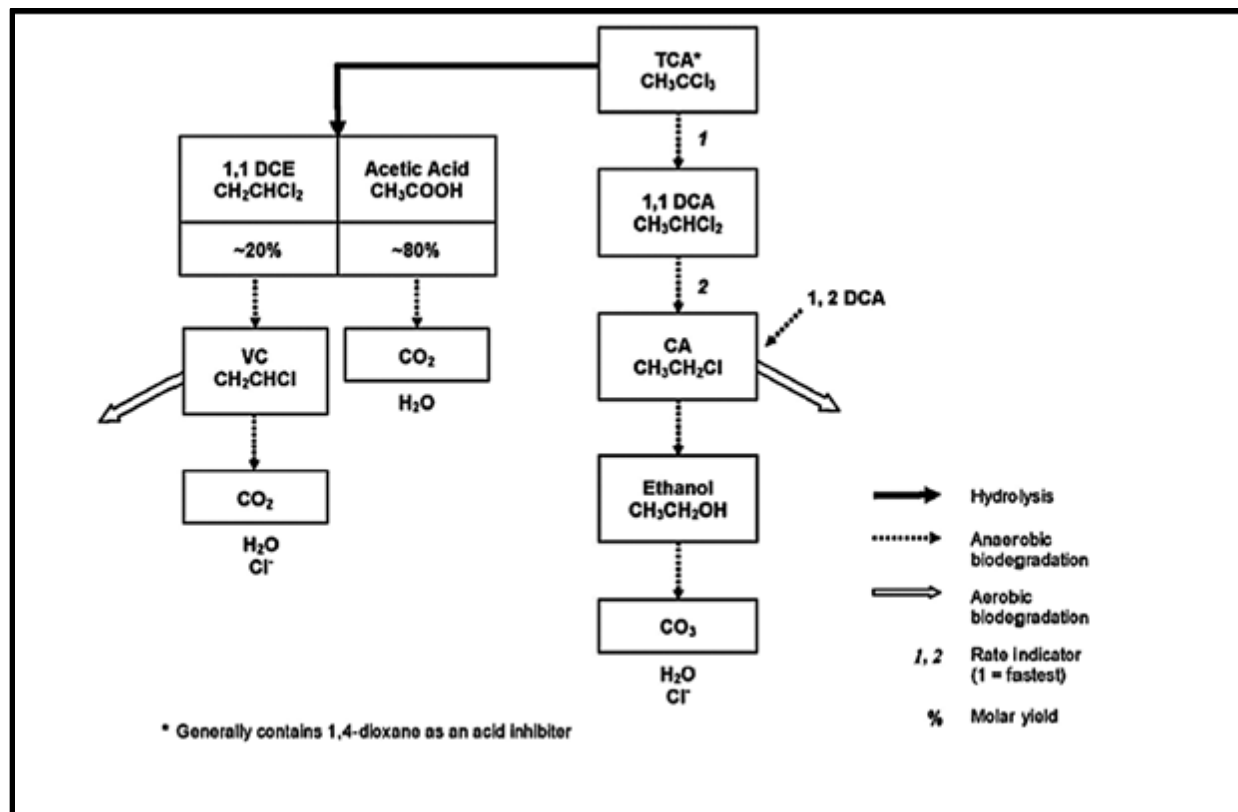


Figure 24. Illustration of the Degradation Pathway of 111 TCA (Morrison, 2006)

Further, Morrison 2006 shows that PCE and TCE are also biodegraded anaerobically. This produces the breakdown products trans 1,2 DCE/cis 1,2 -DCE and VC, and eventually ethene (Morrison, 2001) (See Figure 25). It can take decades for PCE to degrade to VC (Boethling, 1991) under anaerobic conditions. However, VC is less degradable than PCE and tends to accumulate (Deustch, 1997). VC it is very recalcitrant to further degradation to ethene.

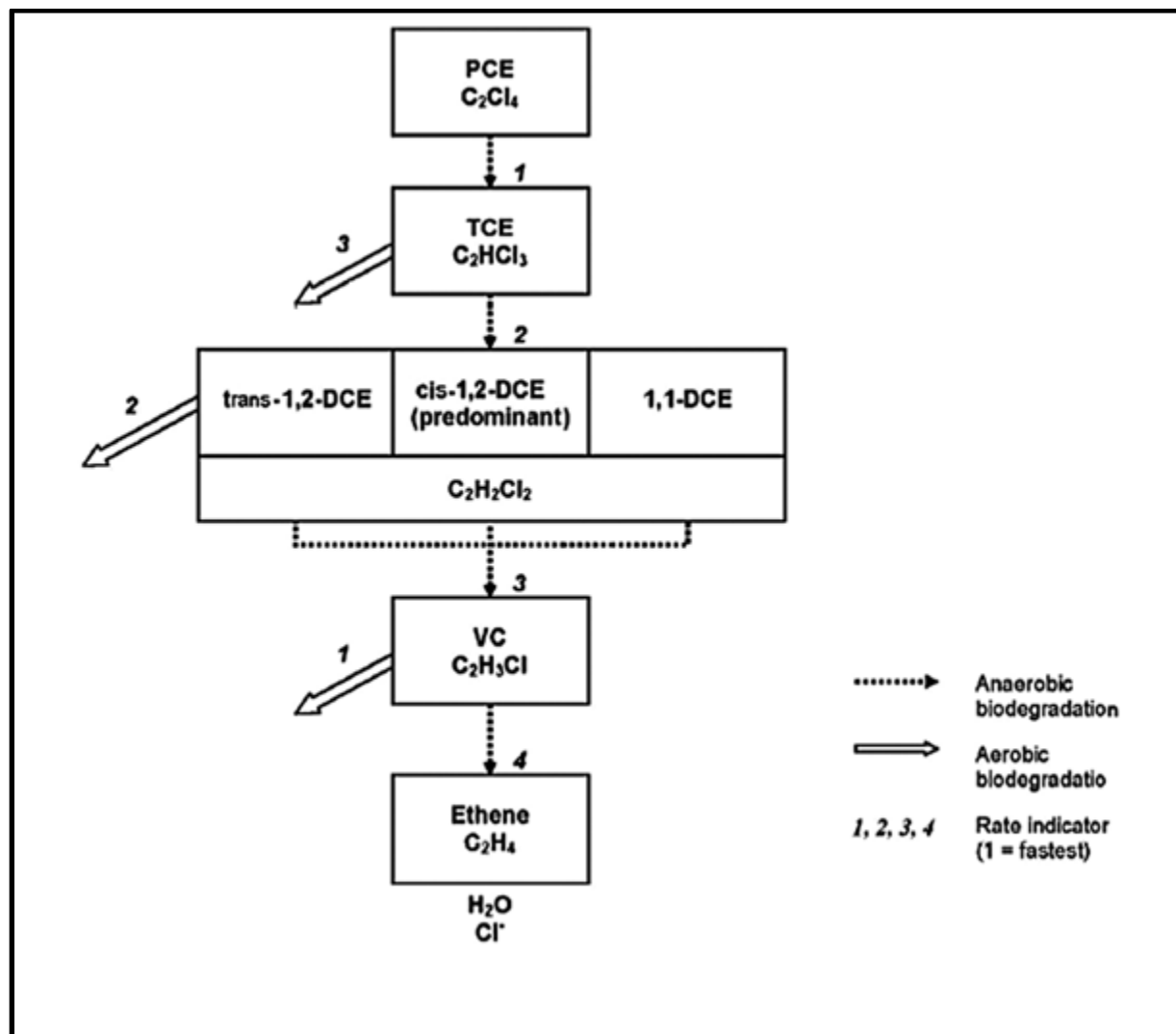


Figure 25. Illustration of the Degradation Pathway of PCE (Morrison, 2006)

Conceptually, a graph of concentrations (mg/L) down the center line of a PCE and associated degradate contaminant plume, that is migrating down gradient from the 300 West site over time (t), should look like the following (See Figure 26):

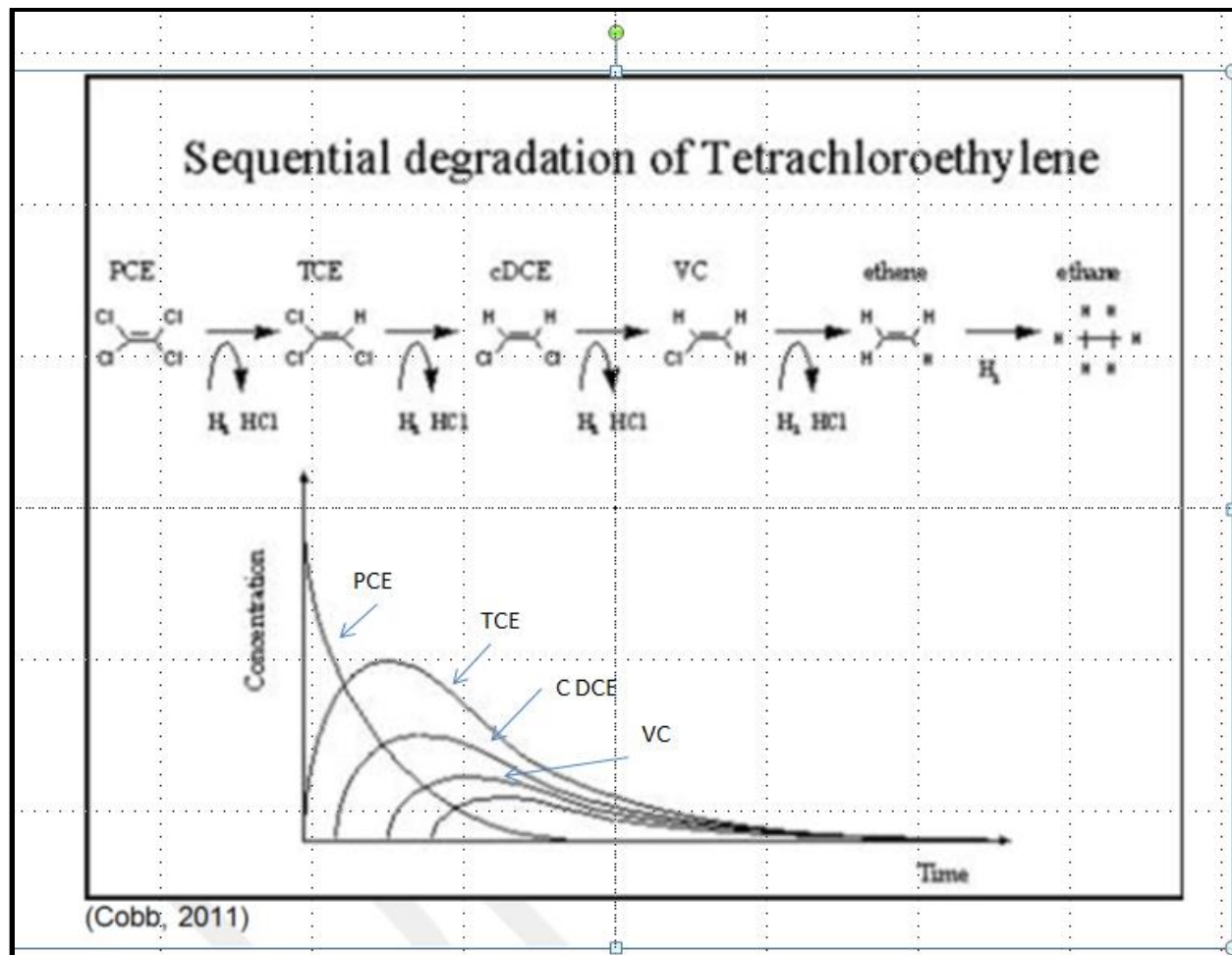


Figure 26. Graph Illustrating PCE Contaminant Mass Decreasing Due to Dispersion and also Transforming as it moves Down Gradient (Cobb, 2011)

This graph shows the parent product PCE at the source as it moves down gradient, and is reduced in concentration via dispersion and anerobic degradation. The graph also shows additional contaminants (e.g., TCE, cis 1, 2 DCE, and VC) as they appear, increase, peak, and then decrease over time down gradient due to sequential degradation and dispersion.

IX. Fate and Transport of 1, 4 Dioxane

The behavior of the fate and transport of 1,4 D (i.e. cyclic ether) is different than the chlorinated solvents described above because of its high solubility, resistance to adsorption, and biodegradation (Mohr, 2010). When released into the environment, 1,4-D is expected to fully mix with the groundwater column. A 2-8% solution of the stabilizer 1,4 D is mixed with 111 TCA, as Mohr 2001 indicates:

Industrial solvents used in degreasing, electronics, metal finishing, fabric cleaning, and many other applications are commonly formulated with additives to enhance their performance. These additives, known as *solvent stabilizers*, serve to prevent solvent breakdown and to inhibit reactions that may degrade solvent properties. Many solvent stabilizer compounds are present at volumetrically inconsequential proportions to be considered significant for solvent release site investigation and cleanup. One ether stabilizer, 1,4-dioxane, has been included with 1,1,1-trichloroethane (TCA, also called methyl chloroform) in mixtures at 2 to 8% by volume, and has proven to be a contaminant of concern at solvent release sites. Other solvent stabilizer compounds may also be problematic. The

Mohr's 2001 White Paper, provides the following basis for the mobility of 1,4 D:

The hydrophilic nature of 1,4-dioxane, 1,3-dioxolane, tetrahydrofuran, and 1,2-butylene oxide makes these compounds miscible or highly soluble, in either case significantly more soluble than TCA and TCE. The mobility of a compound in the subsurface is directly proportional to its solubility. Hydrophilic compounds are only weakly retarded by sorption during transport. Retardation of chlorinated organics is expected to be directly proportional to the octanol-water partition coefficient (K_{ow}), such that these stabilizers will migrate much more quickly than their host solvents (Jackson and Dwarakanath, 1999).

The physio-chemical properties of 1,4 D versus 111 TCA are detailed in Table 4. Mohr 2010 points out that, 1,4 D is 10,000 times more soluble than 111 TCA.

Table 4. Properties of 1,4 Dioxane and 1,1,1 TCA (U.S. EPA, 2006)

Property	Dioxane	1,1,1-TCA
Molecular Weight	88.1	133.4
Melting Point (°C at 760 mm Hg)	11.8	-30.4
Boiling Point (°C at 760 mm Hg)	101.1	74.1
Flash Point (°C at 760 mm Hg)	5 to 18	none
Density (g/mL at 20°C)	1.0329	1.3
Water Solubility (mg/L at 20°C)	Miscible	950
Vapor Density (air = 1)	3.03	4.54
Octanol-Water Partition Coefficient (K_{ow})	0.27	2.49
Vapor Pressure (mm Hg at 20°C)	30	100
Henry's Law Constant (atm m ³ /mole)	4.88 x 10 ⁻⁶	0.0172

Notes: atm = atmosphere; L = liter; mL = milliliter; mm Hg = millimeters of mercury; g = grams; mg = milligrams

Moreover, Figure 27 (Mohr, 2001 and 2010) illustrates how much farther, and faster 1,4 D will move (i.e. 2,500' down gradient in 15 years) versus 111 TCA (i.e. 1,000' down gradient in 15 years) and its breakdown product 1,1 DCA during the same time frame.

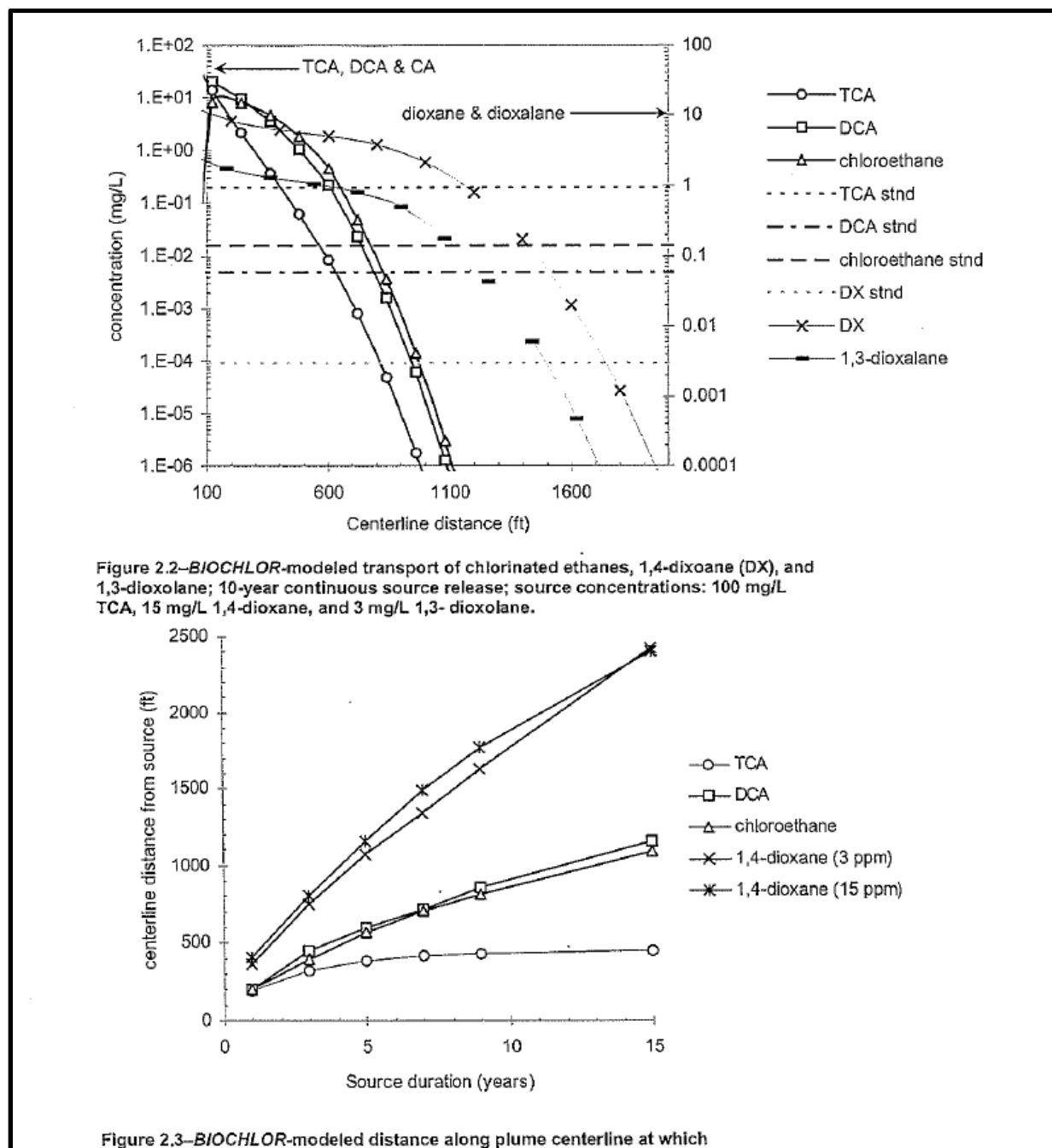


Figure 27. Graphs Showing the Modeled Transport of 1, 4 D versus 111 TCA

Because of its physical and chemical properties (See Table 4), 1,4 D plumes have been documented to measure twice the length of the associated solvent plumes and to affect an area up to six times greater (Walsom and Tunnicliffe 2002). Therefore, defining, capturing, and remediating a plume of 1,4 D in groundwater is considerably more

challenging than the same activities for the associated plume of chlorinated solvent (Walsom and Tunnicliffe 2002).

X. Potential Contamination Sources of VOC's and 1,4 D at 300 West

PRC 1993 provided that raw materials such as 111 TCA were formerly managed in underground storage tanks (UST) at Arnold.

A 1961 map of Arnold shows the location of a 6,000 gallon UST of Chlorothene[®]. This drawing also shows Building 16 where hazardous waste is stored and Building 10 where drum cleaning occurred (See Figure 28). Table V-3 in ENVIRON's 2004 report indicates that UST 9 was approximately installed in 1959⁸, but they could not find a map of the former location. This appears to be UST 9.

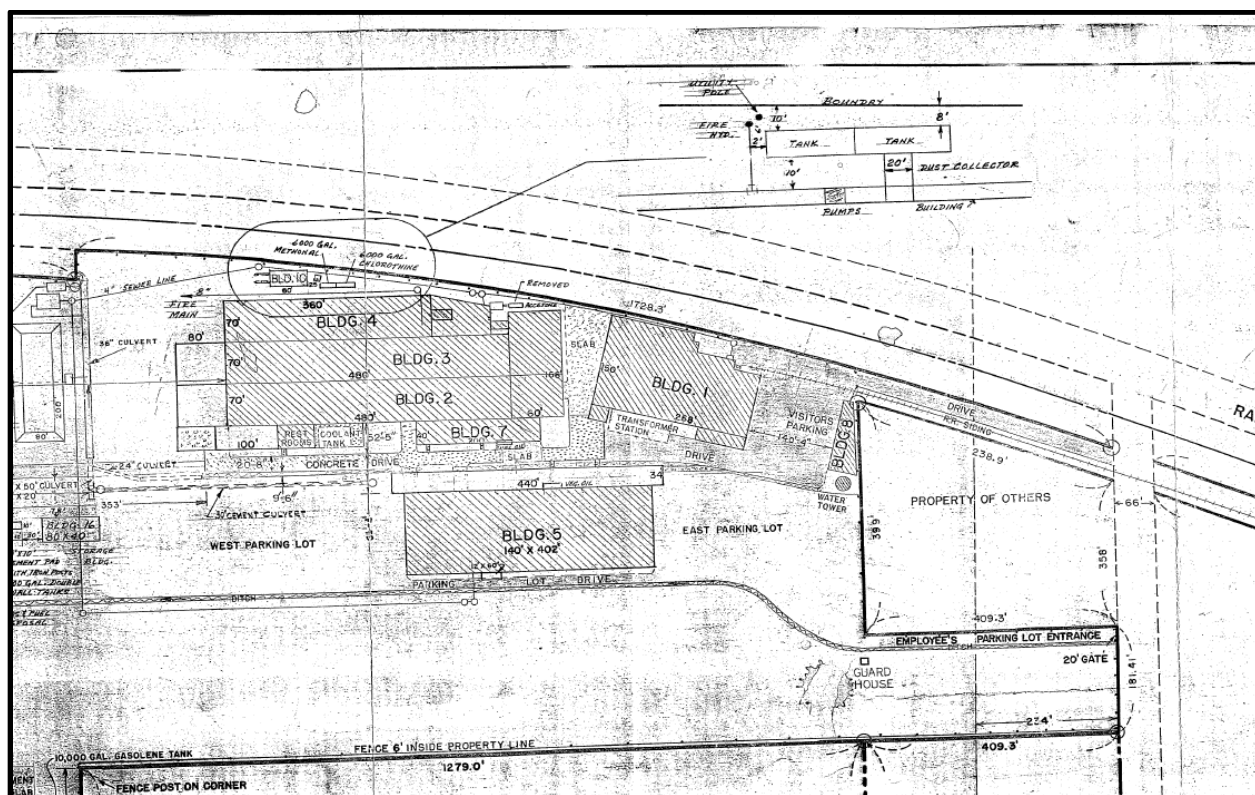


Figure 28. Map of the Arnold Site in 1961 Showing the Location of a 6,000 Gallon (Chlorothene[®]) Tank North of Building 4, Building 10, and Building 16 Hazardous Waste Storage Area

Table 3 in the 1993 PRC report also indicated that spent 111 TCA or Chlorothene[®] was stored in **satellite accumulation areas** in Building 1, 2/3/4/7, 5 and 11/14. Further, PRC's 1993 Report provides that this spent Chlorothene[®] waste was **eventually** stored in Building 16 or the pad west of Building 10.

⁸ **Note:** The first effective TCA stabilizer system for use with aluminum (Bachtel, 1957). Chloroethene NU, introduced by Dow in May 1960, utilized the 1,4-dioxane-based stabilizer system (Chemical and Engineering News, 1962).

Item 5 of a 1995 Arnold Storm Water Inspection Tour and Compliance Memo indicated that drums were found in the Building 6 pit, as follows:

MEMORANDUM

TO: Environmental Committee
FROM: Bob Lipps
DATE: 5/19/95
SUBJECT: Stormwater Plan Inspection Tour and Compliance

=====

L.Jurik,D.Shea of SPS, and I made our annual inspection tour of our site to determine any points of stormwater contact and corrections of these items.

Our inspection tour took place 5/11/95. We started out by the East parking lot in front of Building #1. There were no apparent outside storage locations in this area.

1. Moving over to the East end of Building #5, we found the foundry sand roll-off box. Since this is a non-hazardous waste, it does not need a cover. The shutes carrying revert were covered.

2. On the South side of Building #5 there were several empty drums turned upside down. These are in compliance. D.Shea would like to see these eliminated.

3. 10 drums of mixed Alnico scrap were covered with plastic covers awaiting shipment to Greenville Metals for remelting.

4. Non-flammable gas cylinders were stored in a cage at the West end of Central Stores. Flammable gas cylinders are stored in a shed by the Pond Pump Shack. These are all in compliance.

5. Several drums were found in the Building #6 pit. These were removed.

6. A covered gondola containing Silectron scrap was to the South of Building #11.

7. Moving East along Building #5, we noticed several covered drums outside of the Tool Room.

Since the plant ground seemed to be in compliance there will be no need for a repeat of the plant tour.

cc:G.Migely,L.Jurik,J.Ormerod,B.Nolan,J.Lombardo,M.Nelson,P.Ross,
T.Pace,D.Shea,SPS

A February 4, 2005 letter from Stephen Brisson (Environmental Health and Safety Coordinator (Arnold) to Beth Unser (Permit Section, Division of Water Pollution Control, Illinois EPA) indicated that demolition of Building 6 was completed in 1996:

Operations at Former Building 6

Building 6 was constructed and in operation from the 1950s through 1993 for processing of hard ferrite materials. The facility was idle from 1993 until being demolished that was completed in April 1996.

This facility was used for...

Figure 29, produced by Arnold, delineates the location of where some tanks were removed:

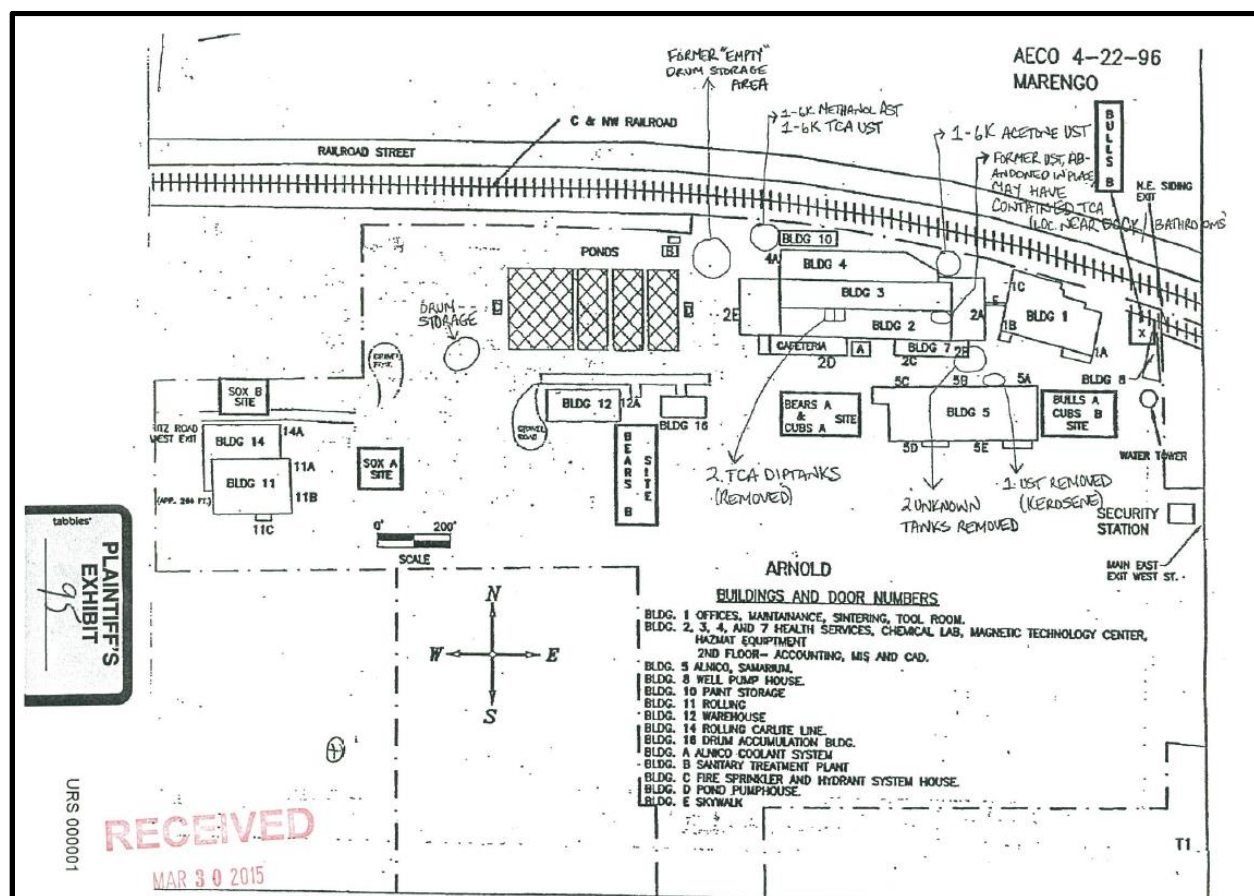


Figure 29. Diagram showing removed tank locations

The UST shown next to Building 10 appears to be Tank 10, by the description provided in ENVIRON's 2004 report.

Figure 30 shows the location of a hazardous waste storage pad west of Building 10 where barrels that were triple cleaned were stored. This figure also shows that this area flows to an unlined ditch. PRC 1993 corroborated that spent 111 TCA used to be stored in this location.

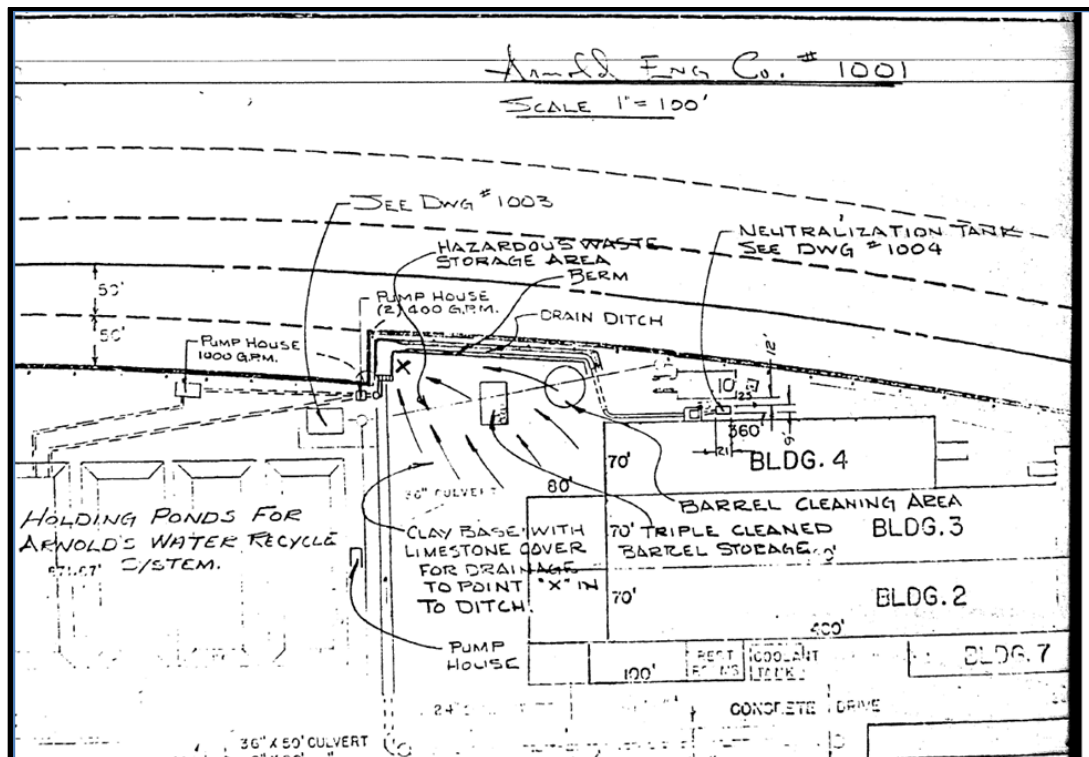


Figure 30. Map Showing the Location of a Hazardous Waste Storage Area, Barrel Cleaning Area, and Cleaned Barrel Storage Area

A March 15, 1996 inspection by the McHenry County Health Department indicated the following regarding the unlined ditch:

Arrived onsite at approximately 10:20 am. Temperatures were in the U40's/L50's, mostly sunny with a slight nly breeze and damp soils. The facility consisted of a number of buildings and lagoons. Wastewater generated is treated and reused onsite. It was learned that a monitoring well network also exists onsite. Facility access is restricted by gate/fencing and security personnel. The inspection was conducted in response to a complaint received alleging the discharge of discolored wastewater into a creek along the north boundary of the facility. The inspection disclosed that discolored wastewater was not being discharged into a creek, rather, it was being discharged into an unlined ditch (see attached site sketch).

The sketch referenced above is illustrated in Figure 31.

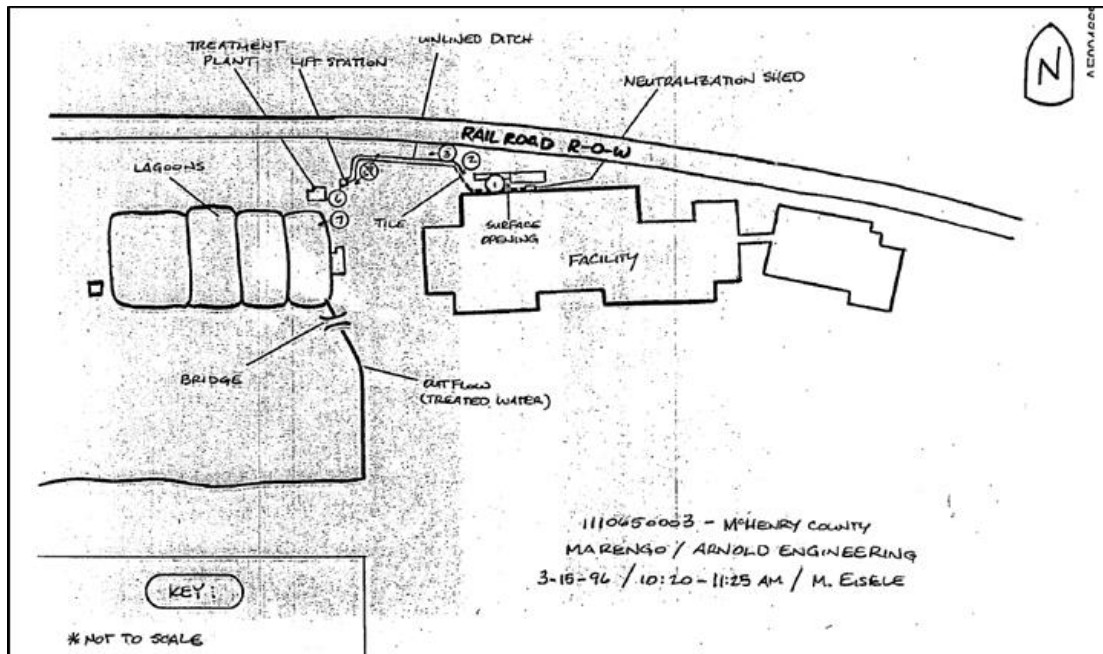


Figure 31. McHenry County Health Department Inspection and Map of an Unlined Ditch

Further, Figure 32 shows where a ferrite waste drum storage area was located adjacent to former building 6:

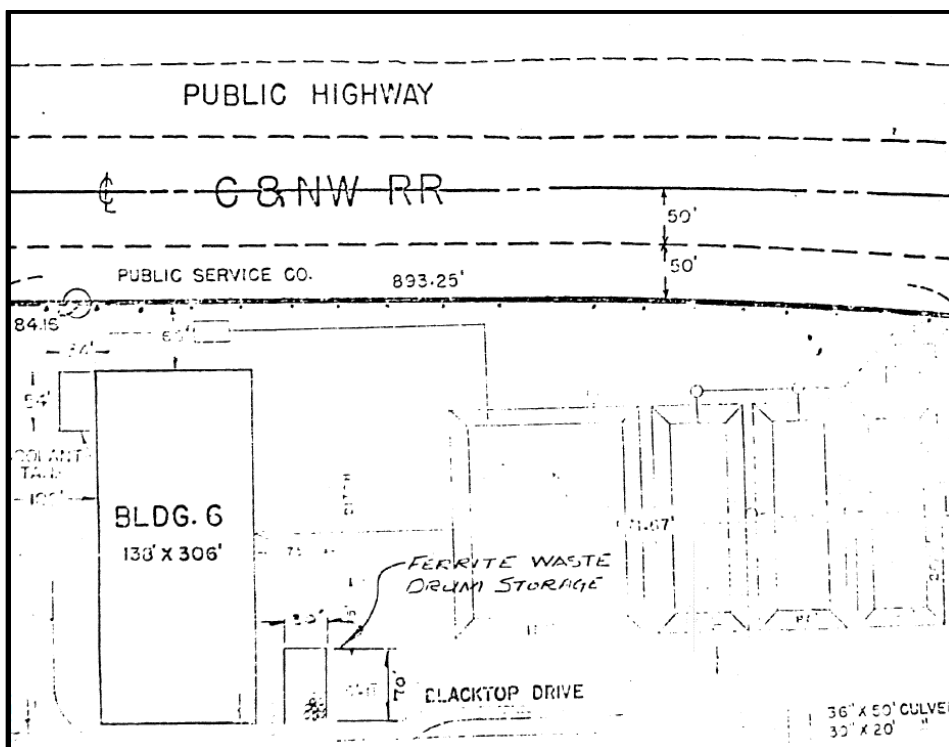


Figure 32 Map Showing the Location of Ferrite Waste Drum Storage near Former Building 6

A 1975 letter from Arnold describing the water recycling system to the Illinois EPA indicates that there was a shallow well at the south-east corner of building 6, and that approximately once a year the contents of a 50,000 gallon coolant tank were slurried with activated carbon applied in an intermediate manhole and discharged to Pond 6 within the red circle (See Figure 33), as follows:

A shallow well located at the south-east corner of building No.6 is used to monitor the percolation field operation.

Approximately once per year, the contents of the 50,000 gal. coolant tank located in building 6 are slurried with activated carbon applied in an intermediate manhole and discharged to pond 6. The wastewater overflow quality data is included in the Schedule N submitted with the original application. The pond is cleaned approximately once every two years (not 3 times a year as indicated on the schematic) with the drag line removed activated carbon used to maintain the integrity of the pond embankments.



Figure 33. Former Arnold Building 6, Coolant Tank and Pond 6

The following 1989 Update of Arnold Recycling System indicates that the “shallow” monitoring well was 150 deep:

Sources of Make-up Water - The Pond #4 overflow (effluent) is derived mainly from the fresh water pumped from our 850' deep well. We lose water due to pond surface evaporation and then gain water from precipitation on the ponds and storm water flows. Under normal dry and stormy weather conditions (less than 100 year storms), there is no perceivable surface discharge from our property. Additional storm water and Pond #4 overflow go back to Pond #5 for percolation. A portion of this excess will overflow (sheet overflow) into our diked six acre field for temporary storage to allow for further evaporation, percolation, and transpiration. No spray irrigation is done. Our shallow monitoring well (150' deep - Bldg. #6) is used to periodically check water bearing strata water quality.

Page V-11 of ENVIRON's 2004 report indicated that there may have been a 111 TCA UST tank in Building 6.

A November 2011, Phase I Environmental Site Assessment and Limited Environmental Compliance Review (ENVIRON, 2011) indicated that:

- **Former Underground Storage Tanks (USTs).** At least 14 USTs are known to have historically been located on-site, which ranged in size from 1,000 to 8,000 gallons and stored mineral oil, acetone, methanol, 1,1,1-TCA, kerosene, gasoline, lubricating oil, and an unknown hazardous substance/solvent. Except for limited soil sampling data related to the closure of one of the two former 1,1,1-TCA USTs, ENVIRON was not provided with sampling data or closure information related to the USTs and therefore cannot rule out the possibility of releases associated with the former USTs. In addition, ENVIRON notes that the site is listed on the Leaking Underground Storage Tank (LUST) database under the name 300 West LLC (the current property owner) for a petroleum product release reported in September 2007, which likely relates to the property owner's closure of three USTs on the subject property at that time. Arnold had no involvement in the 2007-tank closure activities and thus could not provide ENVIRON with associated documentation. Given the absence of closure documentation related to most of the former USTs and the open LUST listing, ENVIRON characterizes this matter as a REC, although parties other than the Company may be responsible for the former USTs and Arnold personnel report that this matter should be covered by the indemnity SPS provided to the Company.

Further, another potential source of groundwater contamination is discussed in an April 4, 2013 e-mail from Arnold's Director of Environmental Health and Safety that documents what was termed; ***their practice*** has been to let metal working fluids drain off a tarp into the ponds, as emphasized below:

Also, I have a bit of a problem with the metal working fluid. Apparently the team didn't understand that we have limits on how much we can use, and this year was a "special year" where we had trouble with the system and they needed to do a lot of change outs. The problem is that ***their practice*** has been to **pump the system out (removing swarf metal, water and metal working fluid), put**

the material that is pumped out on a tarp, and let the liquids drain into the storm drain and into our water treatment system. They've been told, in no uncertain terms, that this practice is to stop, **but I can't fix the sins of the past.** The gallons recorded in our record keeping sheet are gallons of coolant added. 80 drums of "drained" swarf were sent out, and **all the rest of that junk went into our pond system.** Any suggestions for how I should account for this mess would be greatly appreciated.
(Emphasis added)

XI. VOC Contamination

A June 23, 1989 sample of the aforementioned 150 foot deep well adjacent to building 6, showed 9.2 parts per billion (ppb) of 111 TCA. This confirms that 111 TCA was leaking or being dumped for sometime to reach a depth of 150' by 1989.

Moreover, grab samples collected in 1989 of wastewater influent samples showed 111 TCA, methanol, and acetone. As a result Illinois EPA required Arnold to install a network of groundwater monitoring wells, as described in the following:

The Arnold Engineering Company owns and operates a wastewater treatment facility at its magnet manufacturing plant in Marengo, Illinois. The wastewater treatment facility consists of a series of four settling ponds with a capacity of three-million gallons, two overflow ponds, a ten acre diked percolation field and an extended aeration activated sludge treatment plant. Wastewater influent sampling conducted at the facility during August, 1989 indicated that trace amounts of 1,1,1-trichloroethane, methanol, acetone and methylethyl ketone were present in grab samples.

Arnold Engineering received a renewal of their wastewater facility operation permit from the Illinois Environmental Protection Agency (IEPA) in October, 1989. A number of special requirements were cited as conditions of renewal of Water Pollution Control Permit number 1989-EO-3870. One of the special conditions was a requirement to install a network of ground-water monitoring wells around the treatment facility to assess potential impacts the facility may have had on local ground-water quality.

The following memo of March 30, 1990 from Arnold management to ZAP members (i.e. ZAP includes all Arnold employees (Thomas Pace, 2015)) indicates that solvents including Chlorothene® are being put in the ponds and probably down drains:

MEMORANDUM	
TO:	Zap Members
FROM:	Bob Lippe
DATE:	3/30/90
SUBJECT:	PLANT CHEMICAL HOUSEKEEPING

SOLVENTS IN PLANT DRAINS -

Last August, we had to sample incoming water into our recycle ponds plus the pond effluent for the renewal of our recycle water system permit. We found that our incoming pond water sample showed trace amounts of acetone, methanol, methyl ethyl ketone, and 1,1,1,-trichloroethane (chlorothene). These were in parts per billion levels. What this means is that solvents are being put into the ponds, probably down the drains. This must be stopped, since we cannot allow these to get into our underground water. This is part of a preventative program that we have to assure that our ponds do not cause any pollution. We will be monitoring the ponds again in the future to determine if we are eliminating the solvent dumping. No solvents, chemicals, or oils should be put into any drains under any circumstances. We have put a number of signs at many of the plant drains to warn against these activities. If you have any questions, call me or call Maintenance for a waste drum.

On December 6, 1990 VOC samples for MW 2 and 3 showed: 4.6 ppb; and 3.9 ppb, respectively of 111 TCA (Chlorothene®). The stabilizer and corrosion inhibitor in Chlorothene® 1,4 D was not being analyzed.

Sampling results for MW 1, representing up gradient background, shows that the contaminants of concern at this site are not coming from up gradient.

Arnold discontinued the use of 111 TCA in 1991 (PRC, 1993), and switched to using PCE. Although, the 1993 PRC report also indicates that drums of Chlorothene® were still present after that, as emphasized below:

<p>12.9.4 CHLOROTHENE (1,1,1-TCA)</p> <p><u>Rolling Mill - North Bay (Room 201 - ground floor, center of building). Four (4) vapor degreasers (25 to 100 gallon capacities). Adjacent 55 gallon drum stores (1-2 drums). <u>These units are scheduled to be decommissioned in 1993.</u></u></p>
--

A second Arnold interoffice memo dated April 15, 1991 indicated that trace amounts of solvents such as Chlorothene® and Acetone are still being detected in the ponds:

INTEROFFICE CORRESPONDENCE

PLEASE READ AT ZAP MEETINGS

TO: Managers/Supervisors
FROM: Bob Lippe
DATE: 4/15/91
SUBJECT: PLANT WASTE HANDLING

KEEP SOLVENTS AND PAINTS OUT OF PLANT DRAINS

We are still detecting trace amounts of solvents, such as acetone and chloroethene, entering the ponds. These solvents are detectable in our pond water analyses. We want to prevent any hazardous chemicals, such as oils, paints, cleaning solvents, or any other chemicals, from entering our pond system unless authorized by me. When in doubt, please call me before putting it down the drain. Do not throw it on the ground or put it in any of our outside ditches or drains. All drains lead to our ponds. It is Company Policy to not pollute our ponds or ground waters. The only proper place to put hazardous materials (chemicals, oils, paints, or solvents) is in specially labeled waste drums. Please call me to determine proper disposal methods for these items.

Operations in Building 6 were discontinued in 1992 (PRC, 1993).

In February 1994, Arnold started to see 1 ppb of PCE in MW 3, only three years after its use began. Likewise a pond grab sample at the same time showed 4.5 ppb of PCE.

ENVIRON's 2004 report alleged that there may have been an UST of 111 TCA located in former Building 6, as follows:

Lower concentrations of TCA have been detected in other on-site monitoring wells located upgradient of MW-3 but downgradient of current and former facility operations, including MW-A4, MW-A6, MW-A7, and MW-A8. All of the monitoring wells at the site, including MW-3, are installed to a depth of approximately 25 feet bgs and screened from 15 to 25 feet bgs. The monitoring wells are installed within the region's most important aquifer, the sand and gravel aquifer, which is present at a depth of approximately 15 to 200 feet bgs in the site vicinity. A source area for the contamination has not been identified; however, the contamination has been detected downgradient of former Building 6, where a former TCA UST may have been located. MW-3 is also located downgradient of the wastewater collection ponds and Building 16, which is used for hazardous and nonhazardous waste storage, formerly including waste TCA.

Per a letter provided to Illinois EPA from Arnold in 2005 the demolition of Building 6 was completed in April 1996.

Review of the data collected from MW 3 shows a **statistically significant**⁹ increase of the concentration of 111 TCA (See Figure 34). The concentration of 111 TCA in MW-3

⁹ "Statistically significant" means that consecutive groundwater sampling data is showing a greater or lesser concentration of a chemical constituent and represents a pattern rather than chance occurrence.

was at 230 ppb by October 1996. This exceeds the numerical groundwater standard of 200 ppb.

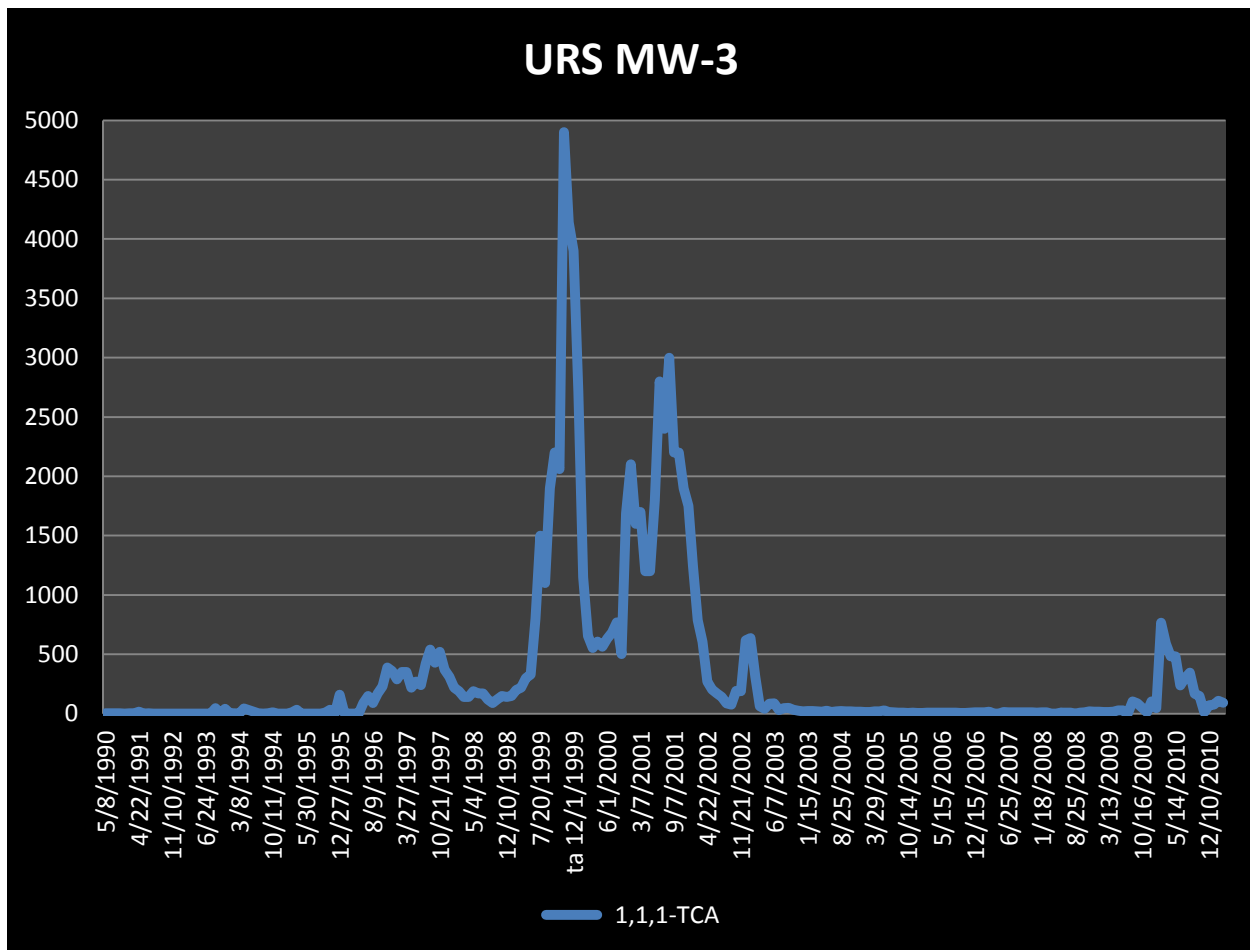


Figure 34. Time Series Graph of 111 TCA in MW 3 (1990-2011)

The graph of 111 TCA in MW3 at 300 West, shown in Figure 34, suggests a one-time source versus a continuous source of contamination, as conceptually illustrated in Figure 21(B). The contaminant mass near the source area detected in MW 3 tails off as the slug of Chlorothene® contamination moved down gradient to the private drinking water supply and irrigation wells.

There is also a statistically significant increase in PCE and TCE in MW 3. (See Figure 35). This also represents violations of the Class I groundwater standard of 5 ppb for each of these contaminants from 1999 until monitoring stopped in 2011. These graphs suggest a continuous source (Figure 21(A)) to off-site groundwater.

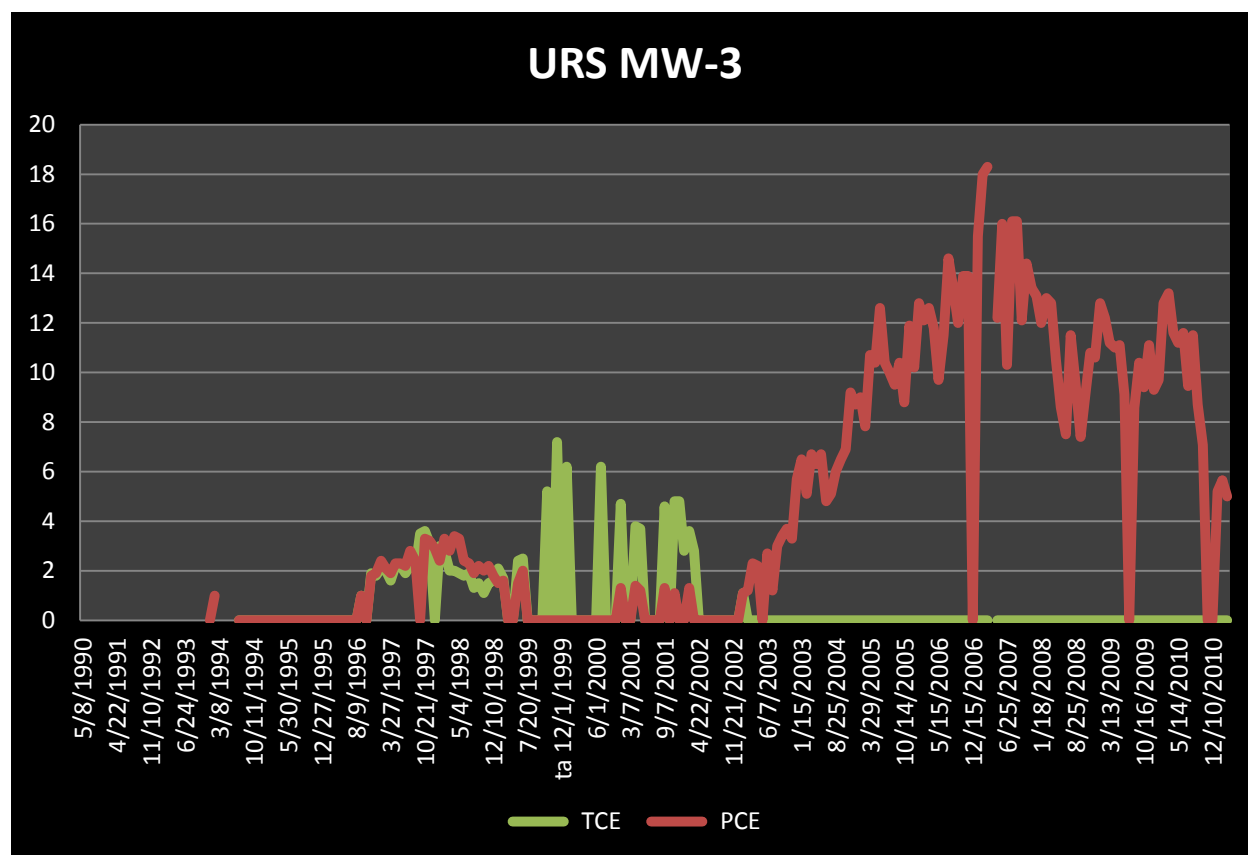


Figure 35. Time Series Graph of PCE (started in 1991) and TCE (started in 1996) in MW 3 (1990 – 2011)

Arnold applied for a TCE permit in 1996. TCE was used with PCE in the Monel process.

As illustrated in Figure 33, the concentration of 111 TCA peaked in MW 3 at 4,900 ppb on November 1999. Arnold hired Environmental Strategies Corporation to sample soil and groundwater using a geoprobe (GP)¹⁰ on November 16 and 17, 1999. GP 6,

¹⁰ "Geoprobe or (GP)" means a hydraulically-powered, direct push machine that use static force as well as dynamic percussion force to drive steel boring rods into the subsurface at variety of depths in order to assist in subsurface sampling. The use of direct push tools makes sampling speeds much faster. Also,

located on the west side of former Building 6 showed 4,100 ppb of 111 TCA at a depth of 18' bgs (ESC, 1999). This GP was installed up gradient of MW 3. Further, 1.5 ppb of TCE was found in GP 8 (ESC, 1999) (See Figure 36). As shown in Figure 32 TCE also exceeded the numerical groundwater standard of 5 ppb in 1999 at MW 3. The GP study and results were not provided to the Illinois EPA.

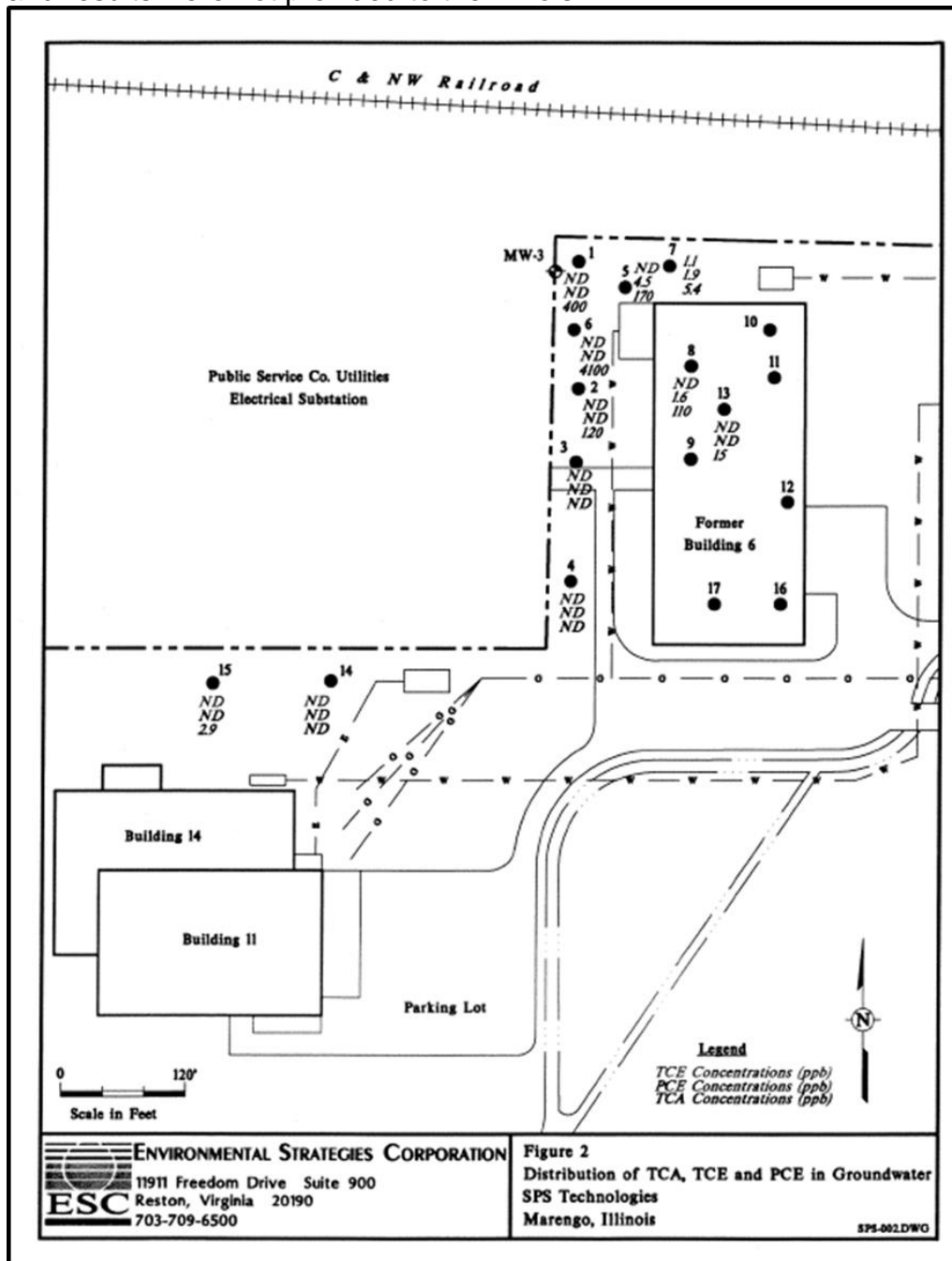


Figure 36. Map of GP Study Relative to Former Building 6 (November 1999)

test borings by direct push technology provides accurate groundwater sample results and defines the water table interface.

A July 12, 2000 Interoffice Memo from Thomas Koraleski to Dennis Shea of SPS indicates:

Another hole was excavated just west of the former coolant pit, in an area where precipitation and manufacturing fluids may have collected when Building 6 was still in operation. It is theorized that solvents might have been discarded and found their way to this depressed area before existing hazardous waste laws were adopted.

Hazardous waste laws were codified in 1976 and 1984. These laws were further amended in 1992 and 1996. The statistically significant increase of 111 TCA in MW 3 started in 1996.

While unaware of the GP Study in 1999, Illinois EPA required Arnold to determine why 111 TCA was being found in MW 3. Thus, Fehr-Graham installed 5 additional MWs and 7 piezometers on May 2001 and July 2001 (See Figure 15). Table 5 shows the results of that study:

Table 5. Results of July 19, 2001 Sampling of New On-Site MWs Upgradient of MW 3 (Fehr-Graham, 2001)

Parameter	MW-3	MW-A4	MW-A5	MW-A6	MW-A7	MW-A8
Carbon tetrachloride	< 20	< 1.0	< 1.0	< 1.0	< 1.0	1.2
Chloroethane	< 40	< 2.0	< 2.0	30	< 2.0	< 2.0
1,1-Dichloroethane	470	< 1.0	< 1.0	180	2.1	< 1.0
1,2-Dichloroethane	< 20	< 1.0	< 1.0	1.6	< 1.0	< 1.0
1,1-Dichloroethene	180	< 1.0	< 1.0	75	< 1.0	3.3
Naphthalene	64	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
1,1,1-Trichloroethane	2,400	1.5	< 1.0	170	19	51
1,1,2-Trichloroethane	< 20	< 1.0	< 1.0	1.4	< 1.0	< 1.0
Trichloroethene	< 20	< 1.0	< 1.0	2.1	< 1.0	< 1.0

Table 5 shows that 111 TCA and its breakdown 1,1 DCE and 1,1 DCA are showing up in MW: A4; A6; A7; and A8 east of Building 6. Although not known at the time of installation, the contaminants in these wells are down gradient of other source area(s) on the Arnold site. The recycle ponds are up gradient of these wells. The information in Table 5 was provided by Thomas Koralewski, Manager, Environmental Compliance at Arnold in an August 30, 2001 letter to the Illinois EPA that indicated the following:

These facts indicate that the TCA is probably migrating from off-site into groundwater under the extreme northwest corner of our property. Bordering our property to the west is a ComEd electric utility substation, with numerous transformers. Bordering our property to the north is a railroad track owned by the Northwestern railroad. We are limited, obviously, on our ability to extend the groundwater investigation beyond our property and, thus, cannot determine the source of the TCA.

The statement above alleges an off-site source of contamination to MW 3. However, there was no mention of the 1999 GP study or the excavation discussed in a July 12,

2000 Interoffice Memo. GP 6 is located directly up gradient of MW 3 in the northwest corner of Building 6. GP 6 showed a concentration of 4,100 ppb of 111 TCA at 18' bgs (ESC, 1999). Further, contaminants coming from ComEd/Railroad would have had to move up gradient, opposite the direction of groundwater flow delineated by Roux 1990 and Fehr-Graham 2001.

It should be noted that a 1989 sample result from the 150' deep well at the south east corner of former Building 6 showed 9.2 ppb of 111 TCA, and the time series analysis of the data from MW 3 installed in 1990 (See Figure 30) shows there were detections of 111 TCA during operations in Building 6, which ceased operating in 1992-93. However, the statistically significant increase of 111 TCA in MW3 is post operation in 1996 when demolition of Building 6 was completed. The concentration peaked in 1999, and the first semi-annual groundwater monitoring report for a sample collected on April 4, 2000 showed that concentration of 111 TCA had decreased to 606 ppb in MW 3.

A September 2001 letter from Arnold (14 years ago) indicated; all three degreasers were replaced with non-chlorinated solvent LEKSOL[®] (n-propyl bromide).

At the request of the Illinois EPA, Arnold installed MW 9 off-site in 2004 to evaluate the impact of the DNAPL 111 TCA contamination found in MW 3 (22' bgs). No VOCs were detected (ND) in off-site MW-9 that was drilled to a depth of 20' bgs. Illinois EPA questioned the shallow depth of the well. Unbeknownst to Illinois EPA, ENVIRON also questioned URS and Arnold about the shallow depth of off-site MW 9, as follows:

Thanks for the data. What is the depth of the off-site well and screened depth? Is there a particular reason that all of the previously existing wells are installed at 25 feet bc:s? Has any deeper ground water been collected? Local hydrogeo info indicates that the shallow aquifer extends from 15 ft to 200 ft bgs, and the downgradient residential wells are installed in this aquifer at depths ranging from 45 to 200 feet bgs.

So why the shallow monitoring wells for likely DNAPL constituents?

Thanks, Alyssa (ENVIRON, December 3, 2004)

(Emphasis added)

In a February 4, 2005 letter from Stephen Brisson (Arnold's Environmental Health and Safety Coordinator) to Illinois EPA he justified MW A9OS, as follows:

Prior to installation of the new wells, all of the existing wells were resurveyed from a common datum and site-wide groundwater level measurements obtained as verification of groundwater flow direction. This information was used in placement of the well MW-A9OS location as being down gradient from well MW-3. Groundwater flow determined during this evaluation is in a north/northwest direction consistent with prior investigations.

Further, Mr. Brisson concluded that 111 TCA had attenuated, as follows:

Arnold Engineering concludes from investigations performed that elevated TCA levels in groundwater at well MW-3 appear to most likely result from past operations at Building 6 and/or from Pond 6. Since 2001 the levels of TCA in well MW-3 have steadily diminished and for the past two years TCA levels in well MW-3 have been well below the Class I Standard. Investigation of offsite groundwater conditions down gradient of well MW-3 does not indicate the presence of TCA above analytical detection limits. These data indicate that the source that contributed to elevated levels of TCA in well MW-3 over the 1999 to 2002 time period has attenuated to a point where groundwater is not being impacted by TCA above applicable standards.

However, this February 4, 2005 letter from Stephen Brisson does admit that the elevated levels in MW 3 appear to be most likely a result of past operations in Building 6/Pond 6.

E-mails between Alan Kalaczinski and Stephen Brisson (Arnold) during March of 2006 discuss the pH readings in Pond 1 at 4.49 and the overflow at 3.64.

From: Alan Kalaczinski
Sent: Friday, March 24, 2006 12:23 PM
To: Stephen Brisson.
Cc: Michael Kaser; Tim Wilson; 'joseph.stulb@usa.xerox.com'; 'Hynes, Ed'; 'Don_Smith@URSCorp.com'
Subject: RE: Ponds

Steve,

We will do as you advise and stop dumping the acid into the ponds. However, this creates a logistics problem for us that we need to overcome very quickly. We only have 2 totes that we use to gather the spent acid. One is always empty as the other is being filled. Each hold about 250 gallons and are rather ruggedly constructed which is good because of the handling and transportation they experience.

- 1.) We have to find out where we got these and get at least 8 to 10 more as quickly as possible.
- 2.) We have to find out who will be removing them from the campus and if they will be returning the empty totes back to us and on what schedule.

This all has to happen by the middle of next week. If it doesn't we may need to dump 250 gallons into the ponds on Wednesday or Thursday to keep the coating line running.

Regards,
Al.

Moreover, the following e-mail indicates that the 35 percent increase in the acid dumped in the ponds correlates with the increases in MW 7 (i.e. 700 ppb of 111 TCA and 6 ppb of TCE) (See Figures 37 and 38) and most importantly confirms that the ponds leak, as follows:

Al:

Based on discussions today with Joe and Ed and the problems we have been seeing at MW-7 we think the potential exists that the elevated levels in MW-7 may be linked to the pH problems in the pond and, in turn from the acid that is being dumped into the ponds.

As noted there has been a 35% increase in the acid dumped into the ponds over the last 6-8 months. This correlates with the increases at MW-7.

Effective immediately we need to stop all dumping of the acid into the pond. I would like to set-up a conference call on Monday with you and Don (who will be at the plant) to discuss this and look at our next steps. Please advise if Monday 3/27/06 at 10:00 a.m. (cst) is acceptable with you both.

Thanks.

Stephen

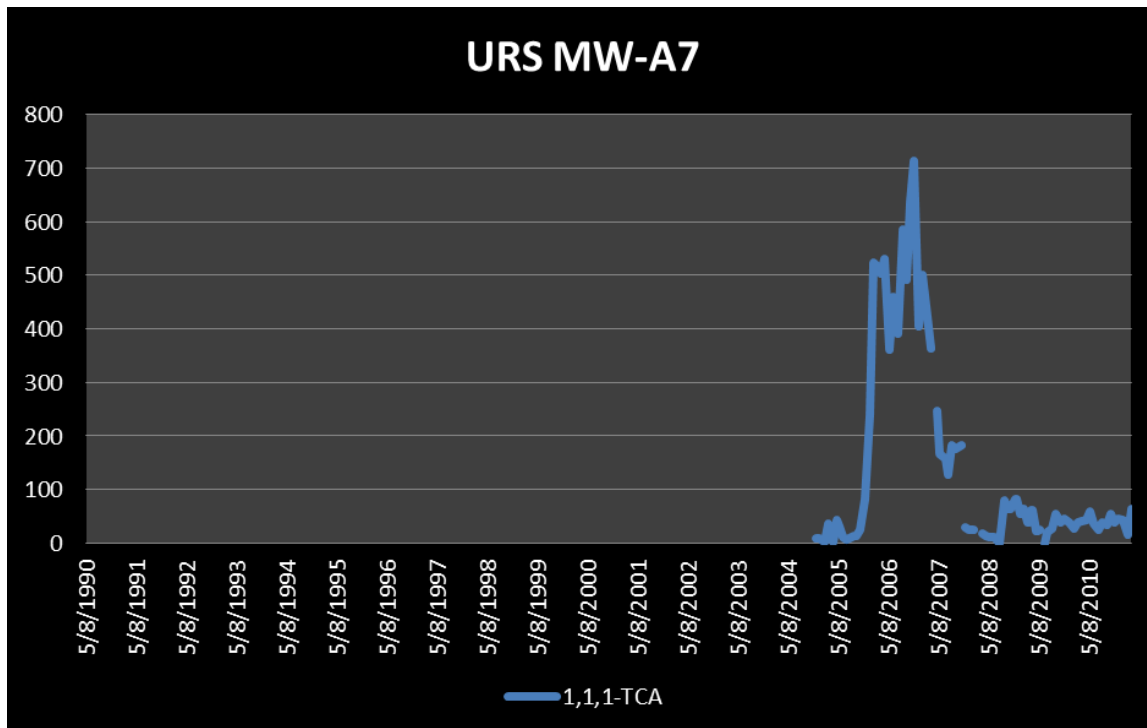


Figure 37. Time Series Graph of 111 TCA in MW-A7 (2004-2011)

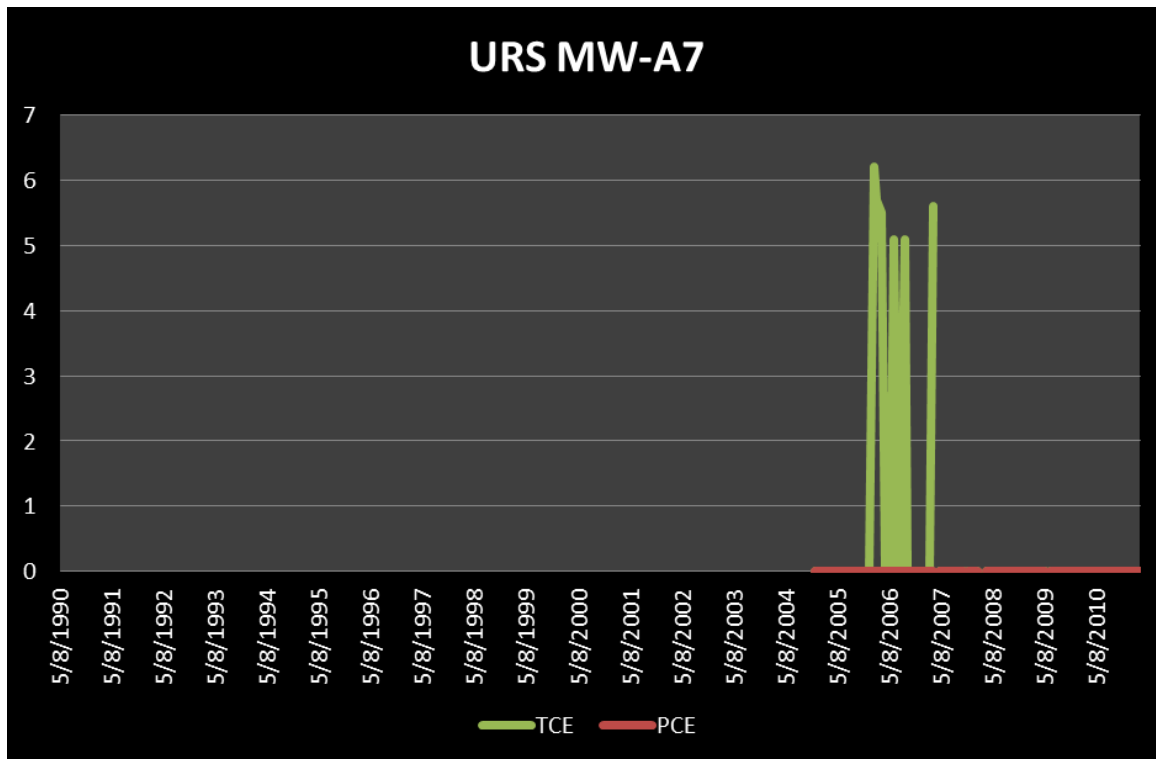


Figure 38. Time Series Graph of PCE and TCE in MW-A7 (2004-2011)

Evaluation of the monitoring data also shows a statistically significant increase of 111 TCA in MW-A8 during this same time frame (See Figure 39).

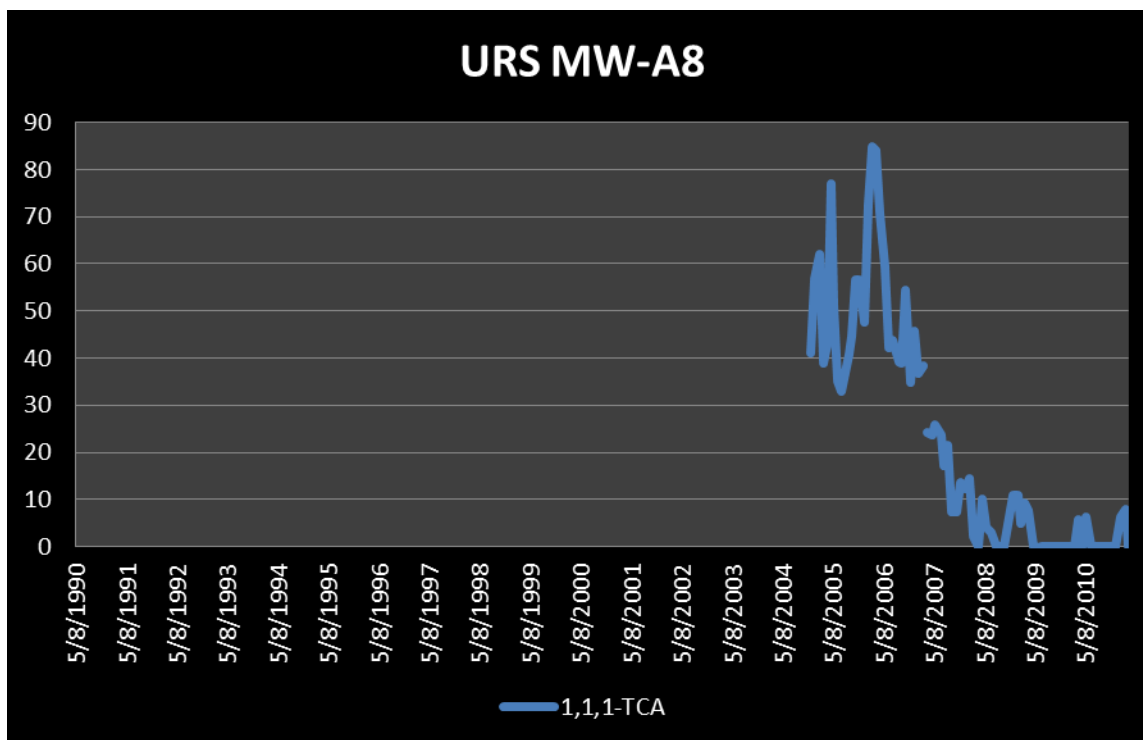


Figure 39. Time Series Graph of 111 TCA in MW-A8 (2004-2011)

On June 19, 2008 the following off-site private wells were sampled for VOCs (Note: this analysis did not include 1,4 D):

Table 6. Off-Site Private Well Results (2008)

Private Well #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)
4210 Ritz Road	118'	ND
4106 Ritz Road	135'	ND
22110 Railroad Street	90'	ND

PCE was detected on September 11, 2009 at 11.1 ppb in MW 3.

In summary, Appendix III shows a map of the original MW 1, 2, 3, A4, A5, A6, A7 and A8 network, installed in 1990 and 2001, and the associated time series of VOC data for each well.

There was a statistically significant increase in 111 TCA in MW 3 in 2010 to over 700 ppb (See Figure 34). PCE was also detected at 13 ppb in MW 3 at the same time (See Figure 35).

On May 3-5, 2010 Earth Solutions installed two nests of 4 MWs in the northwest corner of the site, and on May 10-12, 2010 EGSL installed an additional 8 MWs on-site (EGSL, 2010). Although not known, it is reasonable that 111 TCA is the source of 1,1 DCE via hydrolysis, given the fact that 111 TCA was used from 1961 to 1991 (30 years)¹¹, was found at 9.2 ppb in an onsite well at a depth of 150' in 1989, and was at a concentration of 4,900 ppb in 1999 in MW 3 (22' bgs) at the northwest corner of the site. Further, 111 TCA at on-site MW 31 is still showing levels of 111 TCA at 7,900 ppb in 2015 and in down gradient and off-site MW 83 is at a concentration of 1,500 ppb in 2015 (discussed later). Comparatively, PCE was only used at the site from 1991 to 2001 (10 years), and was first detected in MW 3 in 1994. Thus, 1,1 DCE is attributed to hydrolysis of 111 TCA in the following table. The new MWs were sampled for VOCs (Note: this analysis did not include 1,4 D). The following table shows the results:

Table 7. On-Site MWs Results (2010)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I GW standard (ppb)	Class I GW standard exceedence
MW 1	50'	1,1 DCE = 17	7	Yes

¹¹ **Note:** The 1993 PRC Report indicates that the Chloroethene degreaser units would not be decommission until 1993.

MW 2	40'	1,1 DCE = 44	7	Yes
MW 3	30'	ND		No
MW 4	20'	111 TCA = 300 1,1 DCE = 36 PCE = 14	200 7 5	Yes Yes Yes
MW 5	50'	1,1 DCE = 13	7	Yes
MW 6	40'	1,1 DCE = 12 TCE = 10	7 5	Yes Yes
MW 7	30'	1,1 DCE = 31 PCE = 120 TCE = 7.8	7 5 5	Yes Yes Yes
MW 8	20'	PCE = 10	5	Yes
MW 9	20'	ND		No
MW10	20'	ND		No
MW 11	20'	ND		No
MW12	20'	ND		No
MW 13	20'	1,1 DCE = 12	7	Yes
MW14	20'	ND		No
MW15	20'	ND		No
MW16	20'	ND		No

Subsequent to EGSL's July 15, 2010 Subsurface Evaluation Report, 5 additional MWs were installed on October 28-29, 2010 (MW 17, 18, 19, 20 and 21) (EGSL, 2010). **MWs 19, 18, 20, and 21 were installed off-site.** MW 17 was installed in the nested well cluster in the northwest corner on-site to a depth of 70' bgs. In addition, on February 23-24, 2011 two additional MWs (MW 22 and 23) were installed. MW 23 was installed with the off-site cluster of wells. MW 22 was installed on-site to a depth of 80-90' bgs (EGSL, 2012).

As described above, in the general direction of groundwater flow, a cluster of off-site MWs were drilled approximately 300 feet from the northwest corner of the Arnold site, and the following VOCs were found (See Table 8) (Note: 1,4 D was not being sampled at the time that these samples were taken). VC is attributed to 111 TCA via biodegradation of 1,1 DCE in the following tables, for the reasons previously described above.

Table 8. Off-Site MW Cluster Results (2010-11)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
21	10-20'	ND		No
20	20-30'	ND		No
19	30-40'	111 TCA = 110 1,1 DCA = 52 1,1 DCE = 16 PCE = 9.2	200 1,400 7 5	No No Yes Yes
18	40-50'	VC = 2.8	2	Yes
23	70-90'	ND		No

On March 31, 2011, due to the contamination found off-site in the clustered MWs 19/18, installed in late 2010 and early 2011 (See Table 8), the following off-site private wells were sampled (Note: 1,4 D was not analyzed):

Table 9. Off-Site Private Well Results (2011)

Private Well #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)
22012 Railroad Street	118'	ND
22104 Railroad Street	107'	ND
22110 Railroad Street	90'	ND

ESGL developed a Right-to-Know (RTK) Response Report published on January 15, 2013 that indicated they used an analytical contaminant transport model (Domenico and Schwartz, 1987) to predict the threat of on-site contamination to off-site private drinking water supply wells from on-site MW 7. Table 7 shows that PCE was at a concentration of 120 ppb in MW 7 in 2010. MW 7 is downgradient of the recycle ponds.

EGSL's RTK Response Report states the following:

VOCs: The maximum plume (in the direction of groundwater flow) of VOCs has been diagramed. It should be noted that the Tetrachloroethene (PCE) exceedance at MW-7, which traveled 1,000 feet before reaching compliance, encompassed all other VOC plumes; as such, only PCE is modeled on the diagram.

:

EGSL has determined that the following addresses are within the modeled plumes:

- ✓ 4106 Ritz Road
- ✓ 4210 Ritz Road
- ✓ 4501 Ritz Road
- ✓ 4805 Ritz Road
- ✓ 4907 Ritz Road
- ✓ 5010 Ritz Road
- ✓ 5011 Ritz Road
- ✓ 5017 Ritz Road
- ✓ 22110 W. Railroad Street
- ✓ 22104 W. Railroad Street
- ✓ 22102 W. Railroad Street
- ✓ 21902 W. Railroad Street
- ✓ 21816 W. Railroad Street

On May 2013, Illinois EPA staff and the facility's consultants conducted sampling of private wells predicted by the modeling to be impacted by the contaminant plume from MW 7 for residents and businesses (Illinois EPA, 2013). 300 West LLC, the Site owner, provided bottled water to residents whose wells had unacceptable levels of VOCs.

On June 2013, the Illinois EPA referred the contamination of residential wells located near the Site to the Office of the Illinois Attorney General (OIAG) for resolution through enforcement (OAIG, 2013). Following the filing of a Complaint in June 2013, Agreed Orders were entered in McHenry County Circuit Court on June 2013, August 2013 and July 2014, requiring the Defendants to:

- Provide bottled water to certain private well owners near the Site,
- Conduct quarterly sampling of certain private wells, and
- Conduct an on-site and off-site investigation to determine the nature of the contamination, including volatile organic compounds (VOCs) and 1,4-dioxane, and the extent of the contamination including the depth (Illinois EPA, 2015).

Tables 12 and 13 show the first quarter of 2015 sampling results for these wells. Thus, the on-site contamination is a continuous source of contamination to the off-site private drinking water system wells, as illustrated in Figure 21(A).

In September and October of 2013 Earth Solutions installed an additional 23 MWs on-site (Note: 1,4 D was not being analyzed at this time). Table 8 details the sampling results associated with those wells, as follows:

Table 10. On-Site MWs Results (2013)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
24	30'	Chloroethane = 86 111 TCA = 27.4 1,1 DCE = 58.6 1,1 DCA = 32.2	200 7 1,400	No Yes No
25	30'	ND		No
26	30'	1,1 DCE = 9.4 PCE = 144, TCE = 18.4	7 5 5	Yes Yes Yes
27	30'	PCE = 6.9	5	Yes
28	30'	ND		No
29	30'	ND		No
30	30'	PCE = 152	5	Yes
31	30'	111 TCA = 8,900, 1,1 DCE = 41.9, PCE = 460	200 7 5	Yes Yes Yes
32	30'	111 TCA = 1,340 1,1 DCE = 103, PCE = 15.6	200 7 5	Yes Yes Yes
33	30'	1,1 DCA = 12	1,400	No
34	30'	Chloromethane = 52.9		
35	30'	111 TCA = 718 1,1 DCE = 231	200 7	Yes Yes
36	30'	PCE = 8.7	5	Yes
37	30'	111 TCA = 980 112 TCA = 8.5 1,2 DCA = 17.7 1,1 DCE = 626 PCE = 602 TCE = 10.5 cis 1,2 DCE = 5.6	200 1,400 7 5 5 70	Yes No Yes Yes Yes No
39	50'	ND		No
40	50'	ND		No
41	50'	1,1 DCE = 86.7, PCE = 323,	7 5	Yes Yes

		TCE = 27	5	Yes
42	50'	ND		No
43	50'	ND		No
44	50'	DCE = 15.2	7	Yes
45	50'	ND		
46	50'	111 TCA = 249 1,1 DCE = 17.7 PCE = 11.7	200 7 5	Yes Yes Yes

MW 31 has the highest contamination level found on-site. This well was installed to a depth of 30' bgs, and the water table was encountered at 21' bgs. Unfortunately GP 106, that was installed to represent the hydrogeology of MW 31/41, only went to a depth of 15' bgs. This boring log is included in Appendix IV.

XII. On-Site/Off-Site VOC Contamination Nexus

The dissolved phase of 111 TCA migrated diagonally downward 18' in 300' (i.e. plume slope of 0.06 feet vertical per feet horizontal) to a depth between 30' to 40' bgs where the degradation and hydrolysis products 1,1 DCA and 1,1 DCE were found (See Table 6 and Figure 19). Further, PCE migrated in a similar fashion and biodegraded to TCE. Subsequently, TCE biodegraded to cis 1,2 DCE or trans 1,2 DCE in the down gradient private and MW wells. This explains why there was ND of VOCs in MW 9. MW 9 was only drilled to a depth of 20' bgs in 2004. The VOC plume was underneath the screened interval. In addition, there were no detections of VOCs in the private wells sampled in 2008 and 2011 because the screened interval of these wells is below the depth of the VOC plume (See Figure 40). (Note: the deeper private wells were not being sampled for 1,4 D at the time) Monitoring wells 20, 21, 19, 18 and 23 up gradient of the private wells were not sampled until recently for 1,4 D. The Chlorothene corrosion inhibitor (1,4 D) was included as an analyte for the first time in 2015, and was detected 1.5 ppb at the 22104 Railroad Street private well. This well is over 100' deep.

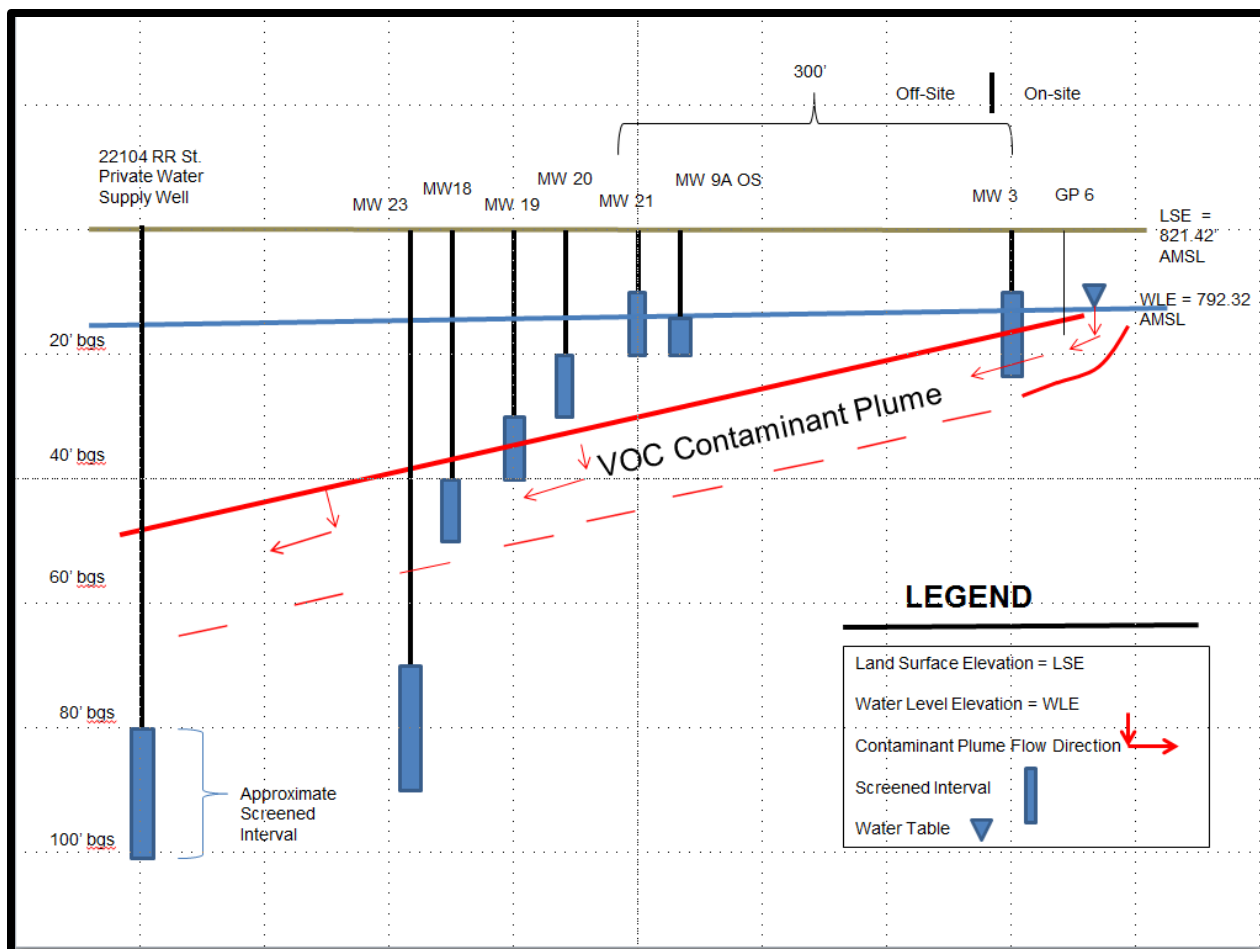


Figure 40. Cross Section Visualizing the Horizontal and Vertical VOC Contaminant Flow Path from 300 West to Off-Site Class I: Potable Resource Groundwater

The 2015 deposition of Tim Pace (page 21), a long time employee of Arnold, indicated that the **practice** was to dump saturated Chlorothene® into outside drains, as emphasized below:

“when the chloroethene got so saturated with oils, **the practice**, I probably did it a couple of times, **was take it out and dump it in the drain outside.**”
(Emphasis added)

Further, pages 50, 51, 52, 53 and 54 of the (Romo, 2015) deposition indicated this regarding the sludge removed from the coolant pit near building 6 that was placed into drums:

Q So there's a reference on Plaintiff's Exhibit 3 to a coolant pit. Was that located adjacent to Building 6?

A Yes.

Q What did you to in the coolant pit?

A **I helped them shovel all that amount of mud, you know, into barrels, and they haul it out of there.**

A The first time when I help them, and that was the only one -- the only time that I helped them, they put the barrels in the street, and **they poke a hole in the bottom, you know, a small hole, and they let it sit there,** and they put covers on it so no more rain water gets in there, and they -- they let it there in the sun, you know, to dry out.

Q And you said they put a hole in the bottom of the barrel?

A **In the bottom of the barrel so it just trickles out, you know.**
(Emphasis added)

Illinois EPA Bureau of Air records documents that the Arnold Permalloy Facility had 3 in-line cold cleaning vapor degreasers (i.e. Machine 504, 1621, and 2874) and the Samarium Cobalt facility had 1 vapor degreaser. Still bottoms would be generated from each of these units. Additionally, the 1993 PRC Report also indicated 4 vapor degreasers with adjacent 55 gallon drum stores of solvent (1-2 drums).

Mohr 2001 and 2010 describes that in vapor degreasers, additives such as 1, 4 D tend to be concentrated in sludge. He also provides that sludge in still bottoms generated from vapor degreasers is composed of 70-80 percent solvent, as follows:

In vapor degreasing systems, stabilizers partition between the vapor phase and boiling liquid phase according to their boiling points. 1,4-dioxane boils at 101° C while TCA boils at 74°C (see Table 2.1). Systems designed to handle heavy loads of oil and grease are designed to distill the solvent for ongoing purification. In such vapor degreasers, additives such as 1,4-dioxane tend to be concentrated in sludges known as still bottoms. In vapor degreasing systems used by the aerospace industry, still bottoms generated by typical in-process distillation is composed of 70% to 80% solvent and 20 to 30% oil, grease, and solids with traces of water. In electronics industry manufacturing using CFC-113, still bottom compositions of 85 - 95% CFC113 with oil and flux comprising 5 to 15% (Jackson, 1999; Evanoff, 1990). Solvents are also reclaimed using activated carbon; however, this technique selectively sorbs some additives, requiring their reintroduction after reclamation.

A May 1995 storm water inspection indicated that there were drums in the Building 6 pit. Per Arnold, the demolition of Building 6 was completed in 1996. ENVIRON's 2004 report also indicated that there may have been a 111 TCA UST tank in Building 6. Subsequently, a 2004 letter from Arnold to the Illinois EPA describes the operation in former operations Building 6/Pond 6 as the most likely source of contamination in MW 3. There was a statistically significant increase of 111 TCA in MW 3 down gradient of Building 6/Pond 6 starting in 1996 and peaking in 1999. Further, GP 6 up gradient of MW 3 showed 4,100 ppb of 111 TCA in 1999.

Analysis of the data in table 8 from late 2010 and early 2011, indicates that 111 TCA migrated downward, biodegraded to 1,1 DCA and transformed via hydrolysis to 1,1

DCE. Then the 1,1 DCE biodegraded to VC which is showing up at a depth of 40-50' bgs. In addition PCE, which Arnold began using more extensively after the phase out of 111 TCA in 1991/1993, moved horizontally and vertically to a depth of 30-40' bgs. Subsequently, the latest results for resamples on March 25, 2015 for MW 19 and April 6, 2015 for MW 18 showed:

Table 11. Off-Site MW 19 and 18 Cluster Results (2015)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
19	30-40'	111 TCA = 18	200	No
18	40-50'	VC = 7.6	2	Yes
23	70-90'	ND		

Therefore as expected, dispersion and degradation over a four year period has reduced the contaminants, initially detected in 2010 and 2011, by an order of magnitude lower concentration of 111 TCA in the high permeability sand and gravel aquifer. Further, 1,1 DCE has biodegraded to VC, and subsequently the concentration of VC has increased. (Note: as described above, VC concentrations can accumulate and is very recalcitrant to further degradation.) Moreover, PCE has dispersed down gradient. (Note: these wells were not sampled for 1,4 D in 2010 and 2011). The 2015 sample analysis did test for 1,4 D, but it was not detected. However, it is reasonable that 1,4 D is not now being detected due to the fact that the Chlorothene[®] only contained a 2-8 percent solution of 1,4 D (Mohr, 2001), and the highly soluble 1,4 D would disperse much more rapidly than 111 TCA. Further, Mohr 2010 emphasizes that:

The effective solubility of 1, 4 Dioxane is 10,000 times greater than 111 Trichloroethane. As a **result 1,4 Dioxane is preferentially removed from the waste mixture; in effect it will suck the 1, 4 Dioxane out of the waste mixture** because of this large difference in effective solubilities.
(Emphasis added)

However, 1,4 D was detected at 1.5 ppb in the down gradient private drinking water supply well (107' bgs) at 22106 Railroad Street in 2015, in the shallower wells on Ritz Road, and in the MCCD IR wells at higher concentrations, as described in the following sections. In addition, it was detected at 39 ppb in MW 99 at a depth of 50' bgs and down gradient of MCCD IR N in 2016. This accumulation of 1,4 D may be illustrating the concept described by Mohr as: preferentially sucking the 1,4 D out of the waste mixture due to the large difference in effective solubilities.

XIII. Private Water Supply Well Contamination

Illinois EPA staff referenced the address data associated with private drinking water supply wells to digital parcels obtained from McHenry County **Geographic Information System**¹² (GIS) (See Figure 41). ArcGIS® was used by Illinois EPA staff to develop the maps in this evaluation.

The VOC contaminant plumes detected in MW 19/18 continued to migrate down gradient toward the private water supply wells. In January 2015, private well contamination (ppb units) showed the parent compounds 111 TCA and PCE, their associated breakdown products, and the 111 TCA stabilizer and corrosion inhibitor “1, 4 D”.

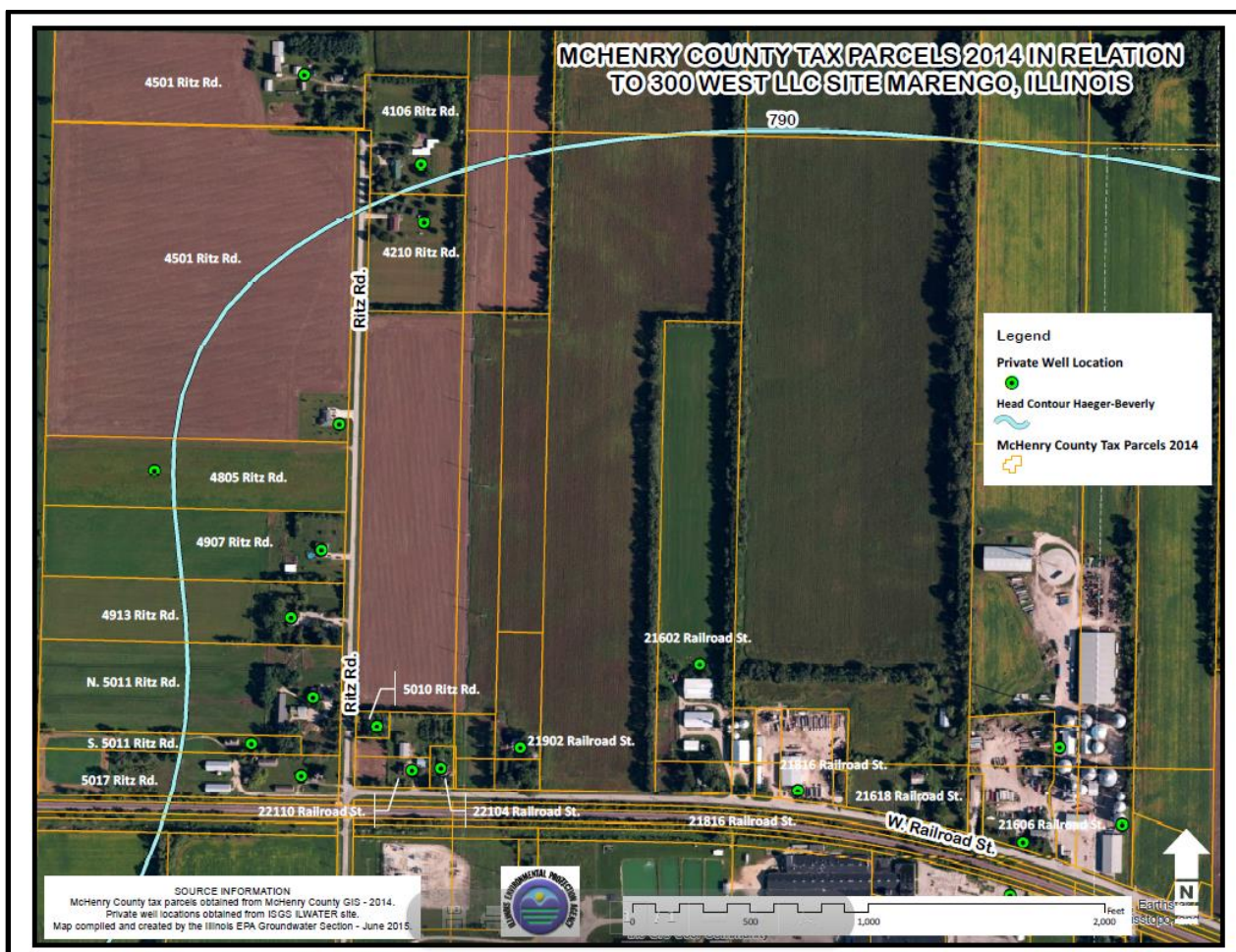


Figure 41. Map Showing Private Drinking Water Supply Wells Sampled North and Northwest of 300 West

The following private well results (located North of 300 West Site), from the first quarter

¹² “GIS” means a system that captures, stores, analyzes, manages and presents data with reference to geographic location data. In the simplest terms, GIS is the merging of cartography, statistical analysis and database technology.

of 2015, show that the deeper wells have either NDs or low levels of the extremely mobile and miscible 1,4 D. The contaminants that are emboldened in Tables 12 and 13 are related to 111 TCA, per the rationale discussed previously. The contaminants related to PCE are not emboldened. Some wells have been hit by both plumes. Further, statistically significant increases of 111 TCA, after its use, at over 700 ppb occurred in MW-A7 in 2006 due to the acid dumped in the recycle ponds. Further, statistically significant increases of PCE occurred consistently starting in 2003 through 2010 in MW 3. Moreover, EGSL modeled 120 ppb of PCE in on-site MW7 to impact down gradient private drinking water system wells in 2013. Additionally, concentrations of contaminants in MW 31, from samples collected in 2013, have very high concentrations of: 111 TCA at 8,900; 1,1 DCE at 41.9 and PCE at 460 ppb (See Table 10).

Table 12. Railroad Street Private Well Results Listed from East to West (2015)

Private Well#	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I groundwater standard exceedence
21602	Unknown Depth - East of Plumes	ND		No
21606	255' - East of Plumes	ND		No
21820	Unknown Depth	ND		No
21816	50'	1,1, DCE = 1.8 1, 4 D = 0.53 TCE = 5.1 cis 1,2 DCE = 1.8 trans 1,2 DCE = 0.58	7 7.7 5 70 100	No No Yes No No
21902	Unknown Depth	1,4 D = 4.33	7.7	No
22012	>120'	1,4, D = 1.02	7.7	No
22104	107'	1,4 D = 1.5	7.7	No
22110	90'	1,4 D = 5.26	7.7	No

However, the shallower wells on Ritz Road show higher concentrations because their well screens are in the contaminant plume(s) flow paths:

Table 13. Ritz Road Private Well Results Listed from South to North (2015)

Private Well#	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I groundwater standard exceedence
5017	25'	1,4 D = 32.88	7.7	Yes
5010	40'	1,1 DCE 4 VC 4.5 1,4 D = 15.72	7 2 7.7	No Yes Yes
5011	40'	111 TCA = 10 1,1 DCE 3.7 previous hits of VC 1.4 D = 1.62 PCE = 0.94 TCE = 1.9	200 7 2 7.7 5 5	No No No No No No
4913	25-35'	111 TCA = 15 1,1 DCE = 51 1, 4 D = 13.69 PCE = 4.5, TCE = 13 cis 1,2 DCE = 22 trans 1,2 DCE = 7.2	200 7 7.7 5 5 70 100	No Yes Yes No Yes No No
4907	65'	111 TCA = ND 1,1 DCE = 72 VC = 1.8 1,4 D = 30.18 TCE = 3.2 cis 1,2 DCE = 20, trans 1,2 DCE = 9.3 1,2 DCA = 1.4 ppb	200 7 2 7.7 5 70 100 5	No Yes No Yes No No No No
4805	55'	1,1 DCE = 2.9 1,4 D = 1.72 cis 1,2 DCE = 1.2 ppb	5 7.7 70	No No No
4210	118'	1,4 D = 3.8	7.7	No
4106	135'	1,4 D = 5.44	7.7	No
4501	180'	ND		No

Appendix V provides a map and associated time series graphs of the contaminants in the private drinking water supply wells listed in Tables 12 and 13.

XIV. Conceptual Hydrogeologic Model

As described above, Illinois EPA staff referenced the address data associated with private drinking water system wells to digital parcels. ArcGIS® was used by Illinois EPA staff to develop the maps in this evaluation. Monitoring well locations were incorporated into GIS using available coordinates, Computer Aided Drawing (CAD) files, via rectification, or digitization from high quality digital aerial photographic maps.

First, the site specific potentiometric surface (Fehr, 2001) was integrated with the regional potentiometric surface (Meyer, 2013) to show the groundwater flow directions from 300 West in the Haeger-Beverly Aquifer (See Figure 42). Although, the Fehr map produced in 2001 was based on a more extensive network of wells than the map produced by Roux in 1990, it should be noted that the 2001 Fehr potentiometric surface is a snap shot because it was only based on one set of readings. In contrast Roux produced more than one set of maps that showed seasonal variation in the potentiometric surface. The groundwater flow direction on-site in the Roux maps shifted from northwest to north after a significant Spring rainfall event (Roux, 1990) (See Figures 10 and 11).

Second, 2 geologic cross sections were developed by Illinois EPA for this hydrogeologic conceptual model. Available geologic well log data from the ISGS was entered into the software RockWorks® to develop these **stratigraphic**¹³ cross sections through the area, and to develop a model of the **hydrostratigraphy**¹⁴ (See Figure 42). These geologic cross sections show the **lithology**¹⁵ of the high permeability Haeger-Beverly Aquifer that 300 West is located on that also extends to the northwest and north of the 300 West site. Further, these cross sections also show the toe of the low permeability Marengo Ridge.

The cross sections were specifically constructed to be generally perpendicular to the equipotential contour lines to show the geologic materials along the contaminant plume pathways from 300 West to off-site. An inset map is included on these figures to show the lines of cross section through the area.

Cross section A'- A starts east at Well 21606, runs along Railroad Street slicing across the northern boundary of 300 West, and then extends northwest, ending at MCCD IR S. This cross section illustrates the composition of geologic materials comprised of highly permeable sand, sand and gravel, and boulders along the contaminant pathway emanating from 300 West to the down gradient private drinking water supply and irrigation wells. EGSL's January 13, 2013 Report indicated the permeability to be 1.49×10^2 ft/d.

¹³ "**Stratigraphic**" means in regard to a sequence of rock layers and layering (stratification).

¹⁴ "**Hydrostratigraphy**" means looking at the relationship of the rock layers with water or hydrology.

¹⁵ "**Lithology**" means a description of the physical characteristics (such as color, texture, grain size, or composition) of a rock unit visible at outcrop, in hand or core samples or with low magnification microscopy.

[illegible]

In 2015, clustered MWs 73/74 was installed between the contaminated private water supply wells and the southern MCCD IR well. Sample results from these wells show:

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
73	30-40'	111 TCA = 7.4	200	No
74	40-50'	1,1 DCE = 22	7	Yes

		VC = 7.8 1,4 D = 11	2 7.7	Yes Yes
MCCD IR S	55'	1,1 DCE = 13 VC = 5.7 1,4 D = 14	7 2 7.7	Yes Yes Yes

Cluster MW 75/76 was also installed in 2015 between contaminated private wells and MCCD IR N. The following VOCs were found in these wells:

Table 15. Off-Site MW 75/75 and MCCD IR N Well Results (2015)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
75	30-40'	ND		
76	40-50'	1,1 DCE = 15 1,4 D = 11 cis 1,2 DCE = 8	7 7.7 70	Yes Yes No
MCCD IR N	55'	1,4 D = 12	7.7	Yes

MWs 83/84 were installed off-site in 2015 almost due north of Arnold buildings 2/3/4/7, 5 and 16. Appendix VI includes GP 394 that went to a depth of 50' bgs. This GP represents the hydrogeology for MW 83/84. Further, these wells are down gradient of where drums were stored and cleaned (Figure 30) and the unlined ditch (Figure 31). These wells are also down gradient of MW 31/41 and MW 32 (See Table 10). The following contaminants were found in these wells (See Appendix VII):

Table 16. Off-Site MW 83/84 Well Results (2015)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
83	30-40'	111 TCA = 1,500 1,1 DCE = 160 1,1 DCA = 92 1,4 D = 9.3 PCE = 190 TCE = 5.7	200 7 1,400 7.7 5 5	Yes Yes No Yes Yes Yes
84	40-50'	111 TCA = 280 1,1 DCA = 390 1,1 DCE 240	200 1,400 7	Yes No Yes

		1,4 D = 290	7.7	Yes
		PCE 7.4	5	Yes
		TCE = 15	5	Yes
		cis 1,2 DCE = 9.2	70	No

Third, past and present contaminant data was averaged and contoured spatially using Surfer® to produce plume boundaries. This is a snap shot, because the movement and degradation of the plume over time from on-site to off-site is transient due to starting and stopping the use of the three solvents,¹⁶ changing water table elevations, seasonal impact of irrigation well pumping, dispersion, and degradation. Figure 43 shows the degreaser 111 TCA, its stabilizer 1,4 D, and the associated breakdown products 1,1 DCE and VC. This map also links on-site groundwater contamination from 300 West to off-site groundwater contamination.

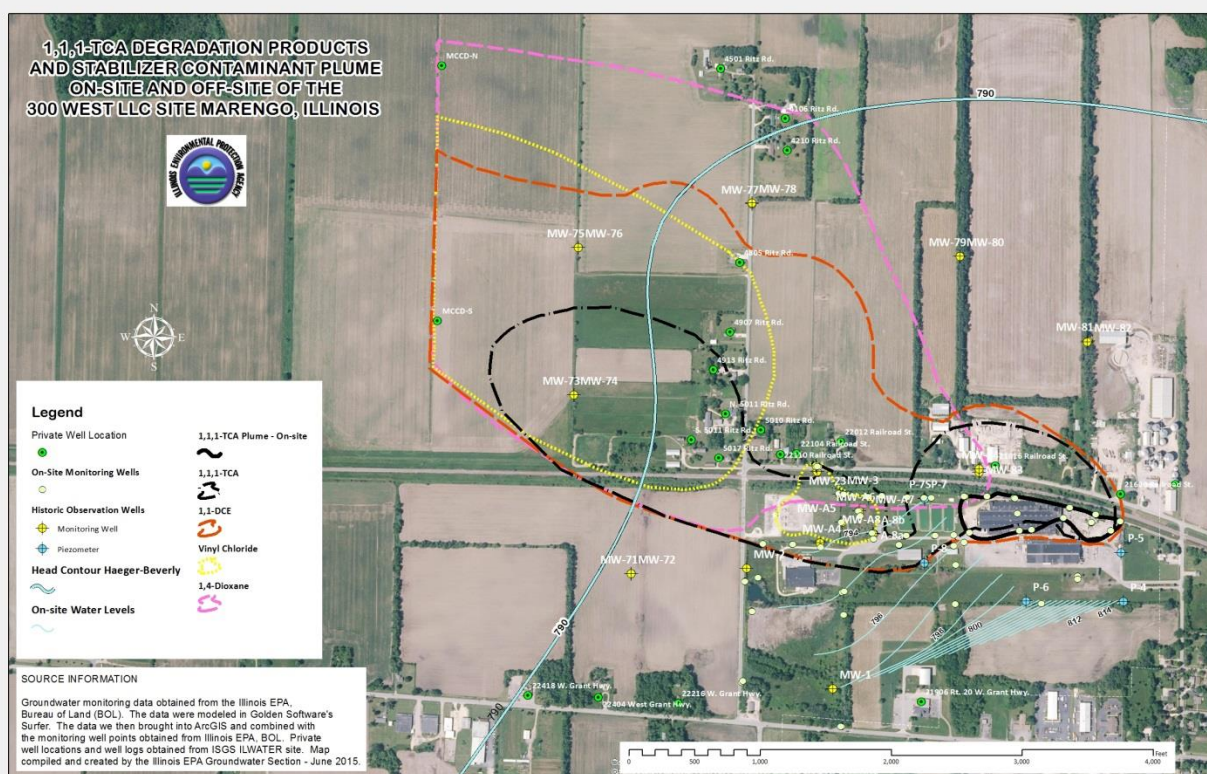


Figure 43. Map Showing the Plume Boundaries of 111 TCA, 1, 1 DCE, VC and 1,4 D Attributed to 300 West

Fourth, Illinois EPA developed a map of PCE and its associated breakdown products. This map also links on-site groundwater contamination from 300 West to off-site groundwater contamination (See Figure 45).

¹⁶ 111 TCA ~1961-1991; PCE ~1991-1996, and TCE ~1996 – 2001.

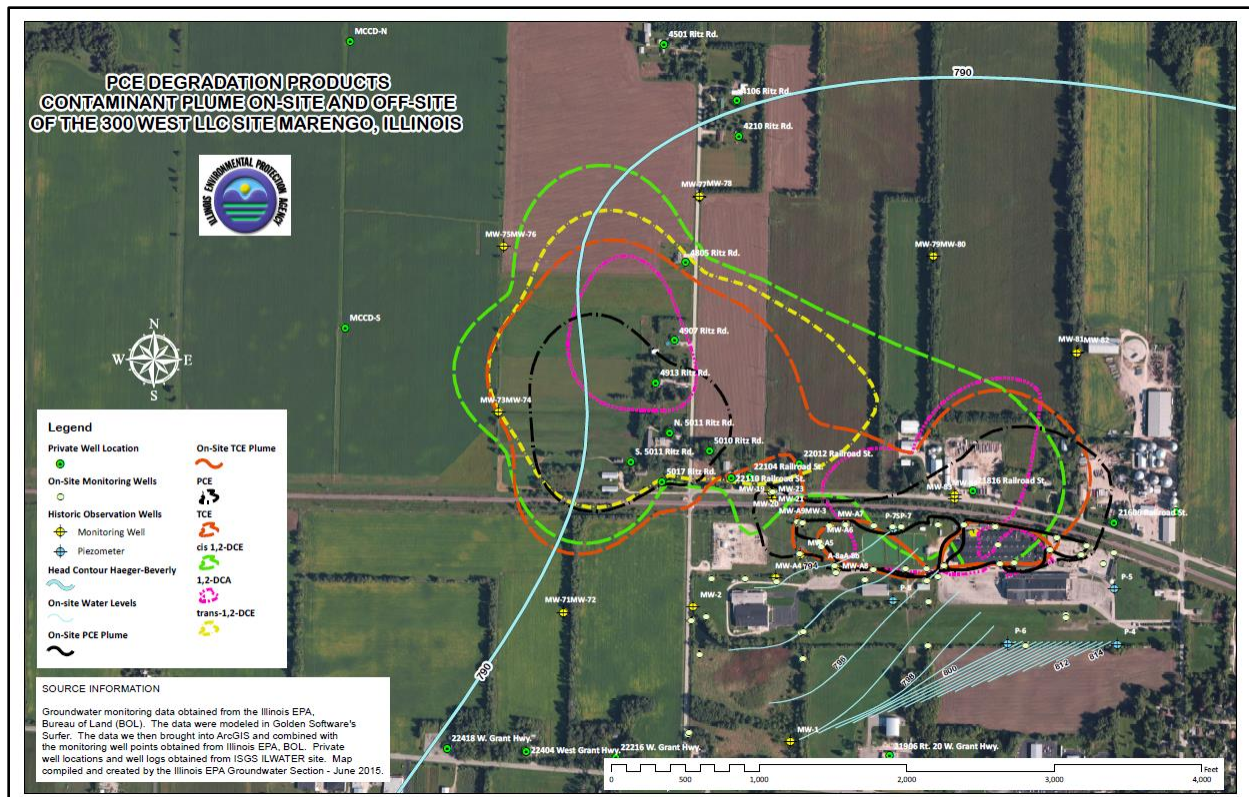
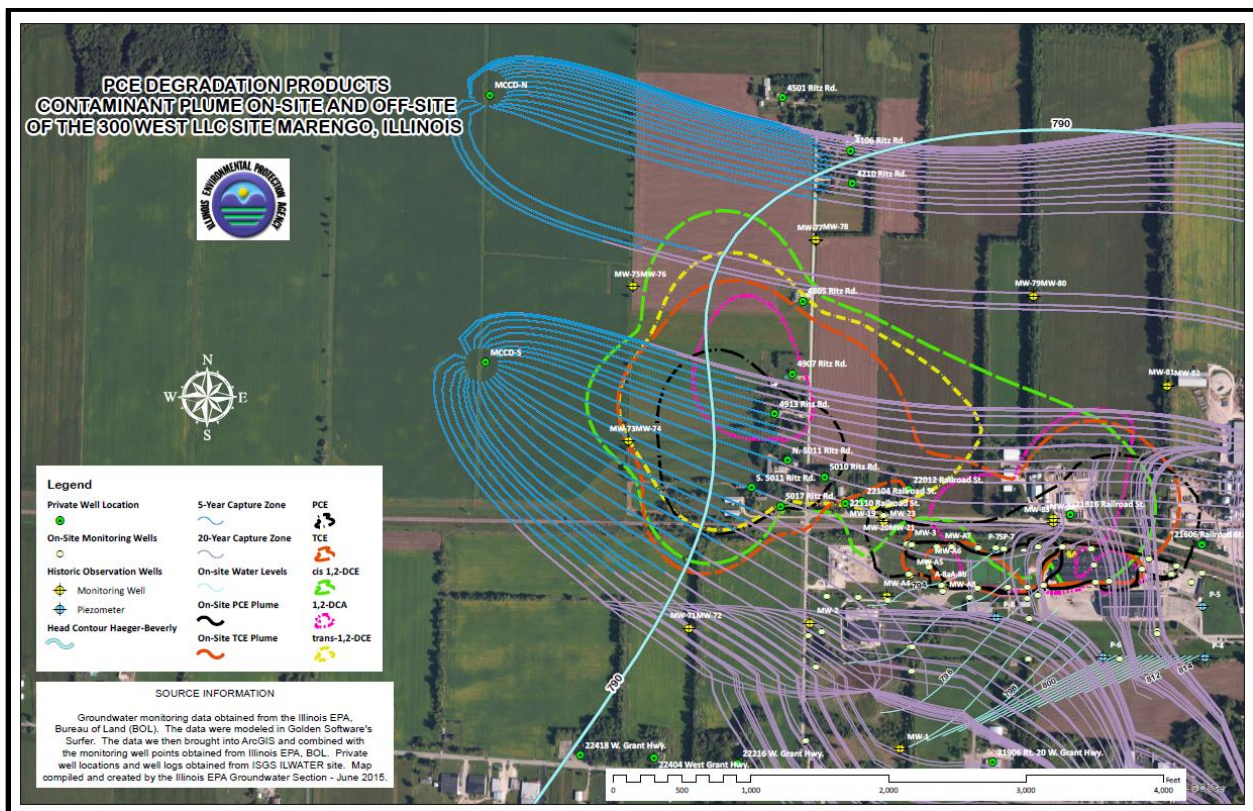
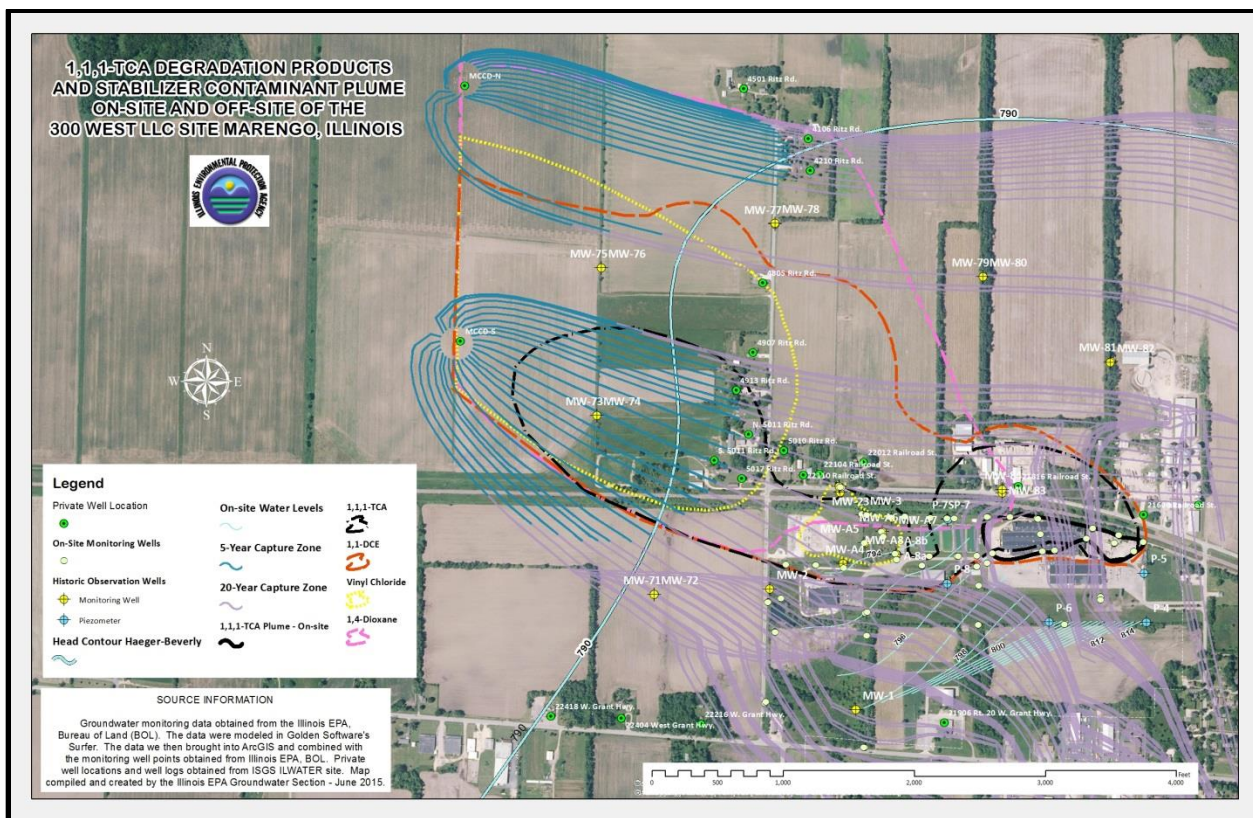


Figure 44. Map Showing the Plume Boundaries of PCE, TCE, cis 1,2 DCE, trans 1,2 DCE and 1,2 DCA Attributed to 300 West

Although the plumes are shown as separate in Figures 43 and 44 they are both present. Both plumes have hit and are present in the private drinking water supply wells.

Fifth, the plume maps above were also integrated with the ZOCs modeled for the MCCD IR N and IR S pumping at 224,400 GPD or 150 gpm (See Figures 45 and 46).



As of May 14, 2015, the solvent-impacted groundwater is present in both the deep and shallower groundwater depths on site. MW cluster 120/121 is located down gradient of Building 16 where hazardous waste is stored. The ZOC of MCCD IR S is pulling groundwater from MW 120/121 down gradient of Building 16 to MW 83/84. Table 15 details the contaminants being found in MW 120/121 (See Appendix VII).

Table 17. On-Site MW 120/121 Well Results (2015)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
120	30-40'	111 TCA = 34 1,1 DCE = 11 1,1 DCA = 190 1,4 D = 34	200 7 1,400 7.7	No Yes No Yes
121	40-50'	111 TCA = 130, 1,1 DCA = ND, 1,1 DCE 7.6, 1,4 D = 19	200 1,400 7 7.7	No No Yes Yes

In addition, the May 27, 2015 sample results from MW 30 (30'bgs) (See Appendix VII) is located where barrel cleaning occurred (See Figure 29) and is also near the unlined ditch (See Figure 30). The ZOC of MCCD IR S is pulling from this area to down gradient MW 83/84. The contaminated private wells on Ritz Road are downgradient of these wells.

Table 18. On-Site MW 30 Well Results (2015)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
30	30	111 TCA = 72 1,1 DCE = 6.6 PCE = 140	200 7 5	No No Yes

The May 27, 2015 sample results from MW 31 (30'bgs) and 41(50'bgs) is located where the former 6000 gallon UST of Chloroethene[®] was located (See Figure 27, Table 19, and Appendix V). The water table was encountered at 21' bgs in MW 31. GP 106 was installed to a depth of 15' bgs to represent the hydrogeology of MW 31/41 (See Appendix IV). The ZOC of the downgradient MCCD-S is also pulling from this area to downgradient private drinking water supply wells.

Table 19. On-Site MW 31 and 41 Well Results (2015)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
31	30	111 TCA = 7,900 1,1 DCE = 260 1,1 DCA = 67 PCE = 330	200 7 1,400 5	Yes Yes No Yes
41	50	111 TCA = 150 1,1 DCE = 48 1,1 DCA = 460 VC = 2.2 1,4 D = 12 PCE = 290 TCE = 36 1,2 cis DCE= 24	200 7 1,400 2 7.7 5 5 70	No Yes No Yes Yes Yes Yes No

MW 3/4 cluster is located in the proximity of historical MW 3, originally installed in 1990 by Roux (See Appendix VII).

Table 20. On-Site MW 3/4 Well Results (2015)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)	Class I groundwater standard (ppb)	Class I GW standard exceedence
3	30-40'	PCE = 12	5	Yes
4	40-50'	PCE = 9.4	5	Yes

Moreover, recent GP sample locations on the northern boundary of the site and within Building 2/3/4/7, shown in Figure 48, and with results detailed in Table 21. Table 21 indicates that the soil is still contaminated with PCE above soil remediation objectives:

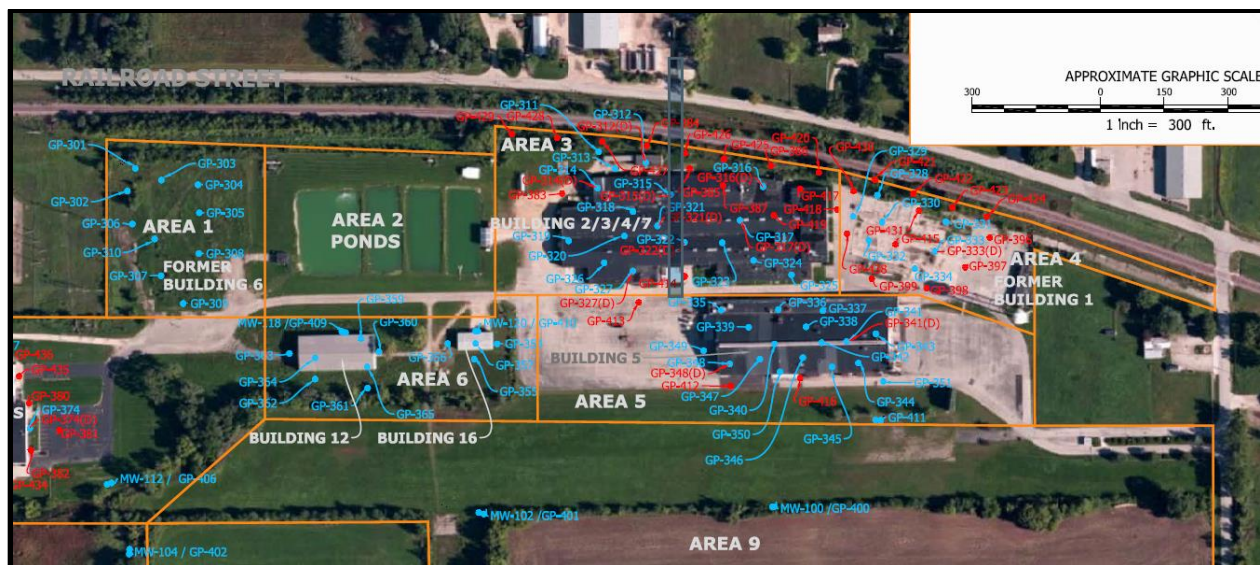


Figure 47. Map Showing the Location of GP Samples Relative to Area 3

Table 21. Results of 2015 GP Samples (milligrams per kilograms (mg/kg))

Geoprobe #	Depth (bgs)	Contaminant	Contaminant (mg/kg)	Soil Remediation Objective (mg/kg)	Area
316	1-3'	PCE	0.24	0.06	3
316	6-8'	PCE	0.20	0.06	3
317	1-3'	PCE	0.10	0.06	3
317	7-9'	PCE	0.087	0.06	3
314	1-3'	PCE	0.10	0.06	3
314	8-10'	PCE	0.24	0.06	3
315	1-3'	PCE	0.21	0.06	3
315	4-6'	PCE	0.29	0.06	3
327	13-15'	1,1 DCE	0.15	0.06	3
425	Varied depths	PCE	4.6 -20	0.06	3
426	Varied depths	PCE	0.09 - 10	0.06	3
420	Varied depths	PCE	0.08	0.06	3
422	Varied depths	PCE	0.084 – 0.48	0.06	4
429	Varied depths	PCE	0.059	0.06	3

During 2015, the following up gradient background MWs were installed and sampled by WCG (See Appendix V):

Table 22. On-Site Up Gradient Clustered MW Results (2015)

MW #	Depth bgs (feet)	VOCs Detected (ppb) (Note: Emboldened Relates to 111 TCA and not embolden relates to PCE)
100	30-40'	ND
101	40-50'	ND
102	30- 40'	ND
103	40- 50'	ND
104	30-40'	ND
105	40-50'	ND
106	30-40'	ND
107	40-50'	ND
108	30-40'	ND
109	40-50'	ND
110	30-40'	ND
111	40-50'	ND
118	30-40'	ND
119	40-50'	ND
122	30-40"	ND
123	40-50'	ND

WCG (May 2015) indicates that:

Additionally, the analytical data obtained during these on-site groundwater assessment activities did not identify solvent-impacted groundwater on the western or southern portions of the Property, which suggests that the solvent-impacted groundwater may be situated more in the vicinity of the current and historical manufacturing buildings and wastewater treatment ponds located on the northern portions of the Property.

New MWs were installed after the original network (i.e. Roux and Fehr-Graham) shown in Appendix III. Appendix V provides a snap shot of data collected from these new MWs and private wells centric to 300 West.

XV. Conclusion

No VOC or solvent stabilizer has been detected up gradient (south) of 300 West (See Table 22) through the Marengo Ridge Aquitard. The VOC contaminant and associated solvent stabilizer plumes are moving from 300 West to off-site Class I groundwater

through the highly permeable geologic materials in the direction of groundwater flow. The natural groundwater flow is toward the Kishwaukee River where it discharges, but it is also clear that the contaminant plumes are being intercepted by the ZOCs of the MCCD IR wells when they are pumping during the growing season. The Chloroethene[®] solvent stabilizer and corrosion inhibitor 1, 4 D has also moved to the north below the depth of the MCCD IR well (55' bgs) ZOC to private wells 4106 and 4210 Ritz Road (135' and 118" bgs) where it is being found at a concentration of 5.4 and 3.8 ppb. However, it is not being detected in the private well north (4501 Ritz Road) of that is 180' bgs.

The boring log for on-site MW 31 shows 2' of brown gray coarse sand and pebbles underlain by 7' feet of brown gray sandy silt followed by 6 feet of sandy clay (See Appendix IV). The brown sandy clay was wet at 15' bgs which appears to be the water table. This is the toe of the sloping Marengo Ridge. MW 31 is 30 feet deep, and the water level is 21' bgs in this well. A DNAPL pool has accumulated on the sloping subsurface toe of the Marengo Ridge, as illustrated in Figure 23. There would be slow movement down the slope of the sandy silt and sandy clay, but this area is also under the influence of the modeled ZOC for MCCD IR South. These source areas continue to contribute contaminants to off-site groundwater as found in MW 83/84 and private drinking water supply wells on Ritz Road (See Appendix VII).

Thus, Chloroethene[®], PCE, and TCE was leaked or dumped at 300 West. These contaminants moved/moving to the water table through highly permeable soils and geologic materials and are also moving as a DNAPL on fine grained materials, dissolved according to their relative effective solubility's, transformed, and moved/moving horizontally and vertically (in the case of VOC's due to a density greater than water and due to the hydrophilic nature of 1,4 D) off-site where monitoring, private water system, and irrigation wells have been contaminated. To date the full extent of the down gradient groundwater contamination plumes have not been fully delineated since contaminants are still being detected in IR and off-site MW wells beyond the IR wells. The most recent results show 39 ppb of 1,4 D at a depth of 50 bgs near the Kishwaukee River northwest of MCCD IR N.

XVI. References

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APPENDIX I – Curriculum Vitae of Richard P. Cobb

CURRICULUM VITAE of RICHARD P. COBB, P.G.

I. Work Experience

Deputy Division Manager, Division of Public Water Supplies (DPWS), Bureau of Water (BOW), Illinois Environmental Protection Agency (EPA). (5/02- Present) My primary responsibilities include managing the: Groundwater Section. Further, I assist with administering the public water supervision program under the federal Safe Drinking Water Act (“SDWA”) and the Wellhead Protection Program (“WHPP”) approved by the United States Environmental Protection Agency (“U.S. EPA”). The Groundwater Section applies Geographic Information System (“GIS”) programs, global positioning system (“GPS”) technology, hydrogeologic models (3D geologic visualization, vadose zone, groundwater flow, groundwater particle tracking, solute transport, and geochemical models), and geostatistical programs for groundwater protection and remediation projects. The Groundwater Section also continues to operate a statewide ambient groundwater monitoring program for the assessment of groundwater protection and restoration programs. Additionally, my responsibility includes the integration of source water protection with traditional water supply engineering and treatment practices, and to further assist with linking Clean Water Act and SDWA programs.

I also do extensive coordination with federal, state and local stakeholders. I am the Illinois EPA liaison to the Governor appointed Groundwater Advisory Council (“GAC”), and I am the Director’s designee to chair the Interagency Coordinating Committee on Groundwater (“ICCG”). I also coordinate with four Priority Groundwater Protection Planning Committees, Illinois Source Water Protection Technical and Citizens Advisory Committee, and with the Ground Water Protection Council (“GWPC”), Association of State Drinking Water Administrators (“ASDWA”), and the Association of State and Interstate Water Pollution Control Administrators (“ASWIPCA”) to develop and implement groundwater protection policy, plans, and programs. I currently represent the U.S. EPA Region V States on the GWPC Board of Directors. I represent the BOW on Illinois EPA’s: Contaminant Evaluation Group (“CEG”) making Right-to-Know law recommendations; Strategic Management Planning Team; Environmental Justice Committee; GIS Steering Committee; Information Management Steering Committee; and Leadership in Energy and Environmental Design for Existing Building (“LEED-EB”) Committee.

Since starting with Illinois EPA in 1985, I have worked on the development of legislation, rules and regulations. I have also served as a primary Illinois EPA witness before Senate and House legislative committees, and at Illinois Pollution Control Board

("Board") proceedings in the matter of groundwater quality standards, technology control regulations, cleanup regulations, regulated recharge areas, maximum setback zone, water well setback zone exceptions, clean construction and demolition debris, site specific coal ash impoundment closure and corrective action, and coal combustion waste impoundment regulations. Furthermore, I have served as primary Illinois EPA witness in enforcement matters.

Manager, Groundwater Section, DPWS, BOW, Illinois EPA. (9/92-Present) My primary responsibilities included development and implementation of Illinois statewide groundwater quality protection, USEPA approved WHPP, and source water protection program. The Groundwater Section worked with the United States Geological Survey ("USGS") to refine Illinois EPA's ambient groundwater monitoring network using a random stratified probability based design. The Groundwater Section continued to operate a statewide ambient groundwater monitoring program for the assessment of groundwater protection and restoration programs based on the new statistically-based design. I co-authored a *Guidance Document for Conducting Groundwater Protection Needs Assessments* with the Illinois State Water and Illinois State Geological Surveys. I also continued to conduct extensive coordination with federal, state and local stakeholders including the Governor appointed GAC, the ICCG, four Priority Groundwater Protection Planning Committees, Illinois Source Water Protection Technical and Citizens Advisory Committee, and at the national level as Co-chair of the GWPC Ground Water Division to develop and implement groundwater protection policy, plans, and programs. I also served periodically as Acting Manager for the Division of Public Water Supplies. Additionally, the Groundwater Section provided hydrogeologic technical assistance to the BOW Permit Section and Mine Pollution Control Program to implement source water protection, groundwater monitoring and aquifer evaluation and remediation programs. I continued to work on the development of legislation, rules and regulations. I also served as a primary Illinois EPA witness at Board proceedings in the matter of groundwater quality standards, technology control regulations, regulated recharge areas and water well setback zone exceptions. Furthermore, I served as an Agency witness in enforcement matters.

Acting Manager, Groundwater Section, DPWS, BOW, Illinois EPA. (7/91-9/92) My responsibilities included continued development and implementation of Illinois statewide groundwater quality protection, U.S. EPA approved WHPP, and ambient groundwater monitoring program. The Groundwater Section developed the Illinois EPA's WHPP pursuant to Section 1428 of the SDWA and was fully approved by U.S. EPA. Illinois EPA was the first state in U. S. EPA Region V to obtain this approval. I performed extensive coordination with state and local stakeholders including the Governor appointed GAC, the ICCG to develop and implement groundwater protection, plans, policy, and programs. Developed and implemented the establishment of Illinois' Priority

Groundwater Protection Planning Committees. Developed and implemented Pilot Groundwater Protection Needs Assessments. The Groundwater Section also provided hydrogeologic technical assistance to the BOW Permit Section and Mine Pollution Control Program staff to develop groundwater monitoring and aquifer evaluation, remediation and/or groundwater management zone programs. I also served as a primary Agency witness at Board proceedings in the matter of groundwater quality standards and technology control regulations. Additionally, I served as an Agency total quality management (“TQM”) facilitator, and TQM trainer.

Manager of the Hydrogeology Unit, Groundwater Section, DPWS, Illinois EPA (7/88-7/91) Managed a staff of geologists and geological engineers that applied hydrogeologic and groundwater modeling principals to statewide groundwater protection programs. Developed, and integrated the application of GIS, GPS, geostatistical, optimization, vadose zone, solute transport, groundwater flow and particle tracking computer hardware/software into groundwater protection and remediation projects. Conducted extensive coordination with state and local stakeholders including the Governor appointed GAC and ICCG to develop and implement groundwater protection policy, plans, and programs. Developed and implemented a well site survey program to inventory potential sources of contamination adjacent to community water supply wells. Additionally, I worked on the development of rules to expand setback zones based on the lateral area of influence of community water supply wells. Furthermore, I provided administrative support to the Section manager in coordination, planning, and supervision of the groundwater program. I also assisted with the development of grant applications and subsequent management of approved projects. In addition, I assisted the section manager with regulatory and legislative development in relation to the statewide groundwater quality protection program. I also served on the Illinois EPA’s Cleanup Objectives Team (“COT”).

Environmental Protection Specialist I, II, and III, Groundwater Section, DPWS, Illinois EPA. (7/85-7/88) I was the lead worker and senior geologist in the development and implementation of Illinois statewide groundwater quality protection program. I worked on the development of Illinois EPA’s ambient groundwater monitoring network, and field sampling methods and procedures with the USGS. I published the first statewide scientific paper on volatile organic compound occurrence in community water supply wells in Illinois. In addition, I assisted with the development of *A Plan for Protecting Illinois Groundwater*, and the legislation that included the *Illinois Groundwater Protection Act*.

Consulting Well Site Geologist, Geological Exploration (GX) Consultants, Denver Colorado. (3/81-12/83) I worked as a consulting well site geologist in petroleum exploration and development for major and independent oil companies. I was responsible for the geologic oversight of test drilling for the determination and presence

of petroleum hydrocarbons. Prepared geologic correlations and performed analysis of geophysical logs, drilling logs and drill cuttings. Supervised and analyzed geophysical logging. Made recommendations for conducting and assisted with the analysis of drill stem tests and coring operations. In addition, I provided daily telephone reports and final written geologic reports to clients.

Undergraduate Teaching Assistant, Geology Department, Illinois State University. (3/79-3/81) I was responsible for teaching and assisting with lecture sessions, lab sessions, assignment preparation and grading for Petrology, Stratigraphy and Geologic Field Technique courses.

II. Undergraduate Education

B.S Geology, 1981, Illinois State University ("ISU"). Classes included field geology at South Dakota School of Mines and Technology, and Marine Ecology Paleoecology at San Salvador Field Station, Bahamas

III. Post Graduate Education

Applied Hydrogeology, 1984, ISU Graduate Hydrogeology Program

Engineering Geology, 1984, ISU Graduate Hydrogeology Program

Geochemistry for Groundwater Systems, 1986, USGS National Training Center

Hydrogeology of Waste Disposal Sites, 1987, ISU Graduate Hydrogeology Program

Hydrogeology of Glacial Deposits in Illinois, 1995, ISU Graduate Hydrogeology Program

MODFLOW, MODPATH and MT3D groundwater modeling, 1992, USGS National Training Center

24 Hour Occupational Health & Safety Training, 1994

Computer Modeling of Groundwater Systems, 1995, ISU Graduate Hydrogeology Program

Introduction to Quality Systems Requirements and Basic Statistics, 2001, U.S. EPA

Source Water Contamination Prevention Measures, 2001, U.S.EPA, Drinking Water Academy

Fate and Transport Processes and Models, 2006, Risk Assessment and Management Group, Inc.,

National Response Framework (NRF) IS-800.b, 2012, EMI

National Response Plan (NRP), an Introduction IS-800.a, 2007, EMI

National Incident Management System (NIMS) an Introduction IS-00700, 2006, Emergency Management Institute (EMI),

Intermediate ICS for Expanding Incidents IS-00300, 2008, EMI

ICS for Single Resources and Initial Action Incidents IS-00200, 2006, EMI,

Introduction to the Incident Command System (ICS) IS-00100, 2006, EMI

IV. License

Licensed Professional Geologist 196-000553, State of Illinois, expires 3/31/2017

V. Certification

Certified Professional Geologist 7455, Certified by the American Institute of Professional Geologists 4/88

Certified Total Quality Management Facilitator, 5/92, Organizational Dynamics Inc.,

VI. Professional Representation

U.S. EPA Region V States representative on **GWPC Board of Directors** 2015

Chair of the ***Interagency Coordinating Committee on Groundwater (ICCG)*** 2013 to the present.

Illinois EPA liaison to the ***Groundwater Advisory Council*** (1988-present)

Senate Working Committee on Geologic Mapping.

Illinois EPA representative and subcommittee chairman, ***State Certified Crop Advisory Board***, and ***Ethics and Regulatory Subcommittee*** established in association with the American Society of Agronomy/American Registry of Certified Professionals in Agronomy, Crops and Soils (1995 – 2001)

Illinois groundwater quality standards regulations technical work group (1988 – 1991).

ICCG State Pesticide Management Plan Subcommittee for the protection of groundwater.

Illinois EPA representative, **State task group involved with developing the siting criteria for a low level radioactive waste site in Illinois.**

Fresh Water Foundation's Groundwater Information System (GWIS) project in the great lakes basin.

Illinois EPA technical advisor, **four priority regional groundwater protection planning committees** designated by the Director to advocate groundwater protection programs at the local level (1991 – present)

Groundwater Subcommittee of the National Section 305(b) Report, of the Clean Water Act Consistency Workgroup.

Ground Water Protection Council's Wellhead Protection Subcommittee.

Co-Chair, **Groundwater Division of the GWPC** on (September 1997 to 2003)

Chairman, **Illinois' Source Water Protection Technical and Citizens Advisory Committee.**

United States Environmental Protection Agency National Ground Water Report Work Group. One of 10 state representatives serving on a work group sponsored by U.S. EPA headquarters charged with development of a national report to be submitted to the U.S. Congress on the status and needs for groundwater protection programs across the country. (January 1999 to July 2000)

Illinois EPA representative, **Northeastern Illinois Planning Commission Water Supply Task Force.** The purpose of this task force is to assist the Commission in the development of a Strategic Plan for Water Resource Management. (March 1999 to 2001)

GWPC/U.S. EPA Futures Forum Work Group providing input on source water protection for the next 25 years. (January 1999 to 2001)

GWPC/ASDWA work group providing input into the U.S. EPA Office of Ground and Drinking Water Strategic Plan for Source Water Protection. June 2000 to March 2005.

Co-Chair, ***U.S. EPA Headquarters/GWPC/ASDWA/ASWIPCA workgroup to develop the second Ground Water Report to Congress.*** March 2002 –present.

Chair, ***ICCG Groundwater Contamination Response Subcommittee*** responsible for developing a new strategy for responding to groundwater contamination and the subsequent notification of private well owners. March 2002 – April 2002.

Illinois EPA representative, ***ICCG Water Quantity Planning Subcommittee*** working on development of a surface and groundwater quantity- planning program for Illinois. June 2002 – January 2003

Chair, ***ICCG Right-to-Know (RTK) Subcommittee, 2006***

GWPC, Groundwater Science and Research Advisory Board, 2007

Co-chair, Illinois Drought Response Task Force, 2012.

Peer Reviewer for research proposals to the Wisconsin Water Resources Institute. 2012- Present.

VII. Professional Affiliation

American Institute of Professional Geologists

Illinois Groundwater Association

Ground Water Protection Council

National Groundwater Association -Association of Groundwater Scientists and Engineers

Sigma Xi – The Scientific Research Society

VIII. Honors

Sigma Xi - Elected to *Sigma Xi* The Scientific Research Society for undergraduate research conducted and presented to the Illinois Academy of Science. 4/81

Director's Commendation Award - Participation in the development of the City of Pekin, Il. Groundwater Protection Program and commitment to the protection of Illinois groundwater. 7/95

Certificate of Appreciation - Outstanding contribution to the development of the Ground Water Guidelines for the National Water Quality Inventory 1996 Report to

Congress from the United States Environmental Protection Agency Office of Ground Water and Drinking Water. 8/96

Groundwater Science Achievement Award - Illinois Groundwater Association for outstanding leadership and service in the application of groundwater science to groundwater protection in Illinois and in the development of the wellhead protection program and pertinent land-use regulations. 11/97

Certificate of Appreciation - GWPC for distinguished service, remarkable dedication, valuable wisdom and outstanding contribution as a GWPC member, division co-chair and special committee member. 9/99

Drinking Water Hero Recognition - United States Environmental Protection Agency Administrator Carol Browner at the 25th Anniversary of the Federal Safe Drinking Water Act Futures Forum in Washington D.C. 12/99.

Certificate of Recognition - United States Environmental Protection Agency Region V Administrator Fred Lyons for outstanding achievements in protecting Illinois' groundwater resources. 12/99

Exemplary Systems in Government (ESIG) Award - Nomination by the Governor's Office of Technology from the Urban and Regional Information Systems Association (URISA) for the Illinois EPA's Source Water Assessment and Protection Internet Geographic Information System. 6/01

IX. Expert Witness Experience

IN THE MATTER OF: GROUNDWATER QUALITY STANDARDS (35 ILL. ADM. CODE 620), R89-14(B) (Rulemaking). Subject: I served as the principal witness recommending adoption of this Illinois EPA Agency proposal. R89-14(B) was adopted by the Board. The standards became effective January 1991.

STATE OIL COMPANY vs. DR. KRONE, McHENRY COUNTY and ILLINOIS EPA, PCB 90-102 (Water Well Exception). Subject: This case involved obtaining an exception from the owner of a non-community water supply well for placing new underground gasoline storage tanks within the 200-foot setback zone of well. I served as the principal witness for Illinois EPA on this case. The Board granted the exception with conditions.

People vs. AMOCO OIL COMPANY and MOBIL CORPORATION, Case no. 90-CH-79, Tenth Judicial Court, Tazewell County, Illinois. (Enforcement) Subject: Groundwater contamination resulting from releases at above ground bulk petroleum storage terminals resulting in violation of Illinois' Groundwater Quality Standards Regulations (35 Illinois Administrative Code 620). I served as the principal Illinois EPA witness on this case.

The case was settled with a penalty of \$125,000 and the requirement of a comprehensive corrective action program.

IN THE MATTER OF: GROUNDWATER PROTECTION: REGULATIONS FOR EXISTING AND NEW ACTIVITIES WITHIN SETBACK ZONES AND REGULATED RECHARGE AREAS (35 ILL. ADM. CODE 601, 615, 616 and 617), R89-5 (Rulemaking). Subject: I served as the principal Illinois EPA witness supporting adoption of this Agency proposal. R89-5 was adopted by the Board and became effective January 1992.

HOUSE BILL 171 METHYL TERTIARY BUTYL ETHER (MTBE) ELIMINATION ACT, House Environmental and Energy Committee. (Legislation) Subject: This law required the phase out MTBE within 3 years of enactment. I served as a principal Illinois EPA witness in support of the proposed legislation. The legislation was adopted as Public Act 92-0132 on July 24 2001. PA 92-132 required the ban of MTBE within three years.

IN THE MATTER OF: GROUNDWATER QUALITY STANDARDS (35 ILL. ADM. CODE 620), R93-27 (Rulemaking). Subject: I served as the principal Illinois EPA witness recommending amendments of new constituent standards in this Agency proposal.

SHELL OIL COMPANY vs. COUNTY of DuPAGE and THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY, PCB 94-25 (Water Well Setback Exception). Subject: A new underground gasoline storage tank was seeking an exception from the Illinois Pollution Control Board in relation to a private drinking water supply well setback zone. The DuPage County and the Illinois EPA held that the tank would be a significant hazard and opposed the exception. I served as the principal Illinois EPA witness. Shell withdrew the petition from the Board after hearings were held.

People ex rel. Ryan v. STONEHEDGE, INC., 288 Ill.App.3d 318, 223 Ill.Dec. 764, 680 N.E.2d 497 (Ill.App. 2 Dist. May 22, 1997). (Enforcement) Subject: The State brought Environmental Protection Act action against company engaged in business of spreading deicing salt, alleging that salt stored on company's industrial property leaked into area's groundwater supply, thereby contaminating it. The Circuit Court, McHenry County, James C. Franz, J., granted company's motion for summary judgment. State appealed. The Appellate Court, Colwell, J., held that: (1) wells existing before Illinois Water Well Construction Code was enacted are not "grandfathered" in as being in compliance with Code, so as to be automatically subject to testing for groundwater contamination, and (2) fact issues precluded summary judgment on claim arising from alleged deposit of at least 50,000 pounds of salt in pile within 200 feet of two existing water supply wells. Affirmed in part and reversed in part; cause remanded.

People vs. STONEHEDGE INC. Case no. 94-CH-46, Circuit Court of the 19th Judicial Circuit, McHenry County. (Enforcement) Subject: This case involved a violation of the potable well setback zone provisions of Section 14.2 of the Illinois Environmental Protection Act. Stonehedge Inc. placed a salt pile of greater than 50,000 pounds within the 200 foot setback of multiple private drinking water supply wells. I served as an Agency principal witness. Stonehedge Inc. was found to be guilty of violating the setback prohibition in this case and was assessed a penalty of \$1,500 and attorneys fees of \$4,500.

SALINE VALLEY CONSERVANCY DISTRICT vs. PEABODY COAL COMPANY, Case No. 99-4074-JLF, United States District Court for the Central District of Illinois. (Enforcement) Subject: Groundwater contamination from the disposal of 12.8 million tons of coarse coal refuse, slurry and gob. Witness for the Illinois EPA. This is an on-going case.

IN THE MATTER OF: PROPOSED REGULATED RECHARGE AREAS FOR PLEASANT VALLEY PUBLIC WATER DISTRICT, PROPOSED AMENDMENTS TO (35 ILL. ADM. CODE 617), R00-17 (Rulemaking). Subject: I served as the principal Illinois EPA witness supporting adoption of this Agency proposal. The proposal was adopted on July 26, 2001 and became effective September 1, 2001.

IN THE MATTER OF: PROPOSED AMENDMENTS TO TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES (35 Ill. Adm. Code 742), (R00-19(A) and R00-19(B)) (Rulemaking). Subject: I served as a supporting Illinois EPA witness recommending inclusion of MTBE in this Agency proposal.

IN THE MATTER OF: NATURAL GAS-FIRED, PEAK-LOAD ELECTRICAL GENERATION FACILITIES (PEAKER PLANTS), R01-10 (Informational Hearing) Subject: I served as a supporting Illinois EPA witness to discuss the impact of peaker plants on groundwater.

IN THE MATTER OF: GROUNDWATER QUALITY STANDARDS AND COMPLIANCE POINT AMENDMENTS (35 ILL. ADM. CODE 620), R01- 14 (Rulemaking). Subject: I served as the principal Illinois EPA witness recommending amendments of a groundwater standard for MTBE and compliance point determinations in this Agency proposal. The Board adopted the proposal unanimously on January 24, 2002.

TERESA LeCLERCQ; AL LeCLERCQ; JAN LeCLERCQ; WALT LeCLERCQ, individually; and on behalf of all persons similarly situated vs. THE LOCKFORMER COMPANY, a division of MET-COIL SYSTEMS CORPORATION, Case no. 00 C 7164, United States District Court, Northern District of Illinois. (Enforcement) Subject: I was called as a witness by Lockformer Company to testify about a Well Site Survey

prepared and published in 1989 by the Illinois EPA for Downers Grove community water supply.

TERESA LeCLERCQ; AL LeCLERCQ; JAN LeCLERCQ; WALT LeCLERCQ, individually; and on behalf of all persons similarly situated vs. THE LOCKFORMER COMPANY, a division of MET-COIL SYSTEMS CORPORATION, Case no. 00 C 7164, United States District Court, Northern District of Illinois. (Enforcement) Subject: I was called as a witness by Lockformer Company to testify about groundwater contamination in the Lisle and Downers Grove area.

HOUSE BILL 4177 PRIVATE WELL TESTING PROPERTY TRANSFER and DISCLOSURE ACT, House Environmental and Energy Committee. (Legislation)

Subject: Legislation to require volatile organic chemical contamination testing of private wells at the time of property transfer and reporting to the Illinois Department of Public Health and the Illinois EPA. I served as a principal Illinois EPA witness in support of the proposed legislation. The legislation was not supported due to the opposition from the realtors association.

MATTER OF PEOPLE vs. PEABODY COAL, PCB 99-134 (Enforcement). Subject: the State of Illinois developed an amended complaint against Peabody Coal Company (PCC) for violation of the groundwater quality standard for total dissolved solids, chloride, iron, manganese, and sulfate. I developed testimony to address PCC's affirmative defense of challenging the basis for the groundwater quality standards for these contaminants.

IN THE MATTER OF: PROPOSED AMENDMENTS TO TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES (35 Ill. Adm. Code 742) (TACO), (Rulemaking). Subject: I served as the Illinois EPA witness supporting amendments TACO to include wellhead protection areas. September 2004.

IN THE MATTER OF MAXIMUM SETBACK ZONES FOR MARQUETTE HEIGHTS PUBLIC WATER SUPPLY (35 ILL. ADM. CODE 618), R05-09 (Rulemaking). Subject: Pursuant to request by the Village of Marquette Heights the Illinois EPA developed a maximum setback zone for the Marquette Heights community water supply wells. I served as Illinois EPA's principal witness. The proposal was adopted on May 4, 2006.

IN THE MATTER OF: STANDARDS AND REQUIREMENTS FOR POTABLE WATER WELL SURVEYS AND FOR COMMUNITY RELATIONS ACTIVITIES PERFORMED IN CONJUNCTION WITH AGENCY NOTICES OF THREATS FROM

CONTAMINATION UNDER P.A. 94-134 (35 Ill. Adm. Code 1505), R06-023 (Rulemaking), JANUARY 2006. I served as an Agency panel witness to support the adoption of the RTK regulation.

IN THE MATTER OF: PROCEDURES REQUIRED BY P. A. 94-849 FOR REPORTING RELEASES OF RADIONUCLIDES AT NUCLEAR POWER PLANTS: NEW 35 Ill. Adm. Code 1010, R07-20. (Rulemaking) I served as the Agency primary witness in this proceeding.

IN THE MATTER OF: GROUNDWATER QUALITY STANDARDS (35 ILL. ADM. CODE 620), R08-18 (Rulemaking). Subject: I served as the principal witness recommending amendments and updates to the exiting regulation. Thirty nine (39) new contaminant standards were added and wellhead protection areas were included under the compliance determination section. The Board went to First Notice on October 20, 2011. The Board adopted Second Notice on August 9, 2012. These amendments became final on October 4, 2013.

IN THE MATTER OF: IN THE MATTER OF: AMEREN ASH POND CLOSURE RULES (HUTSONVILLE POWER STATION): PROPOSED 35 ILL. ADM. CODE PART 840.101 THROUGH 840.144 (R09-21). (Rulemaking) Subject: I served as the one of principal witnesses on this site specific regulation. These regulatory amendments were adopted by the Board on January 20. 2011.

PEOPLE OF THE STATE OF ILLINOIS vs., EXELON CORPORATION (No. 06 MR 248), Will County Circuit Court. (Enforcement) Subject: I served as one of the primary Illinois EPA technical witnesses in a case where the State of Illinois and Will County sued Exelon for water pollution and exceeding groundwater standards beginning in 2001 at its Dresden Nuclear Generating Station near Morris. Exelon paid more than \$1 million to resolve three civil complaints stemming from radioactive tritium leaks at the Braidwood, Bryon and Dresden nuclear power plants.

IN THE MATTER OF MAXMIUM SETBACK ZONES FOR FAYETTE WATER COMPANY PUBLIC WATER SUPPLY (35 ILL. ADM. CODE 618), R011-25. (Rulemaking) Subject: Pursuant to request by the Fayette Water Company the Illinois EPA developed a maximum setback zone for the Fayette Water Company community water supply wells. I am serving as Illinois EPA's principal witness. The adopted rule was published by the Secretary of State on March 16, 2012.

IN THE MATTER OF: Proposed Amendments To Clean Construction Or Demolition Debris Fill Operations (CCDD): Proposed Amendments To 35 Ill. Adm. Code 1100, R12-9. (Rulemaking) In response to Joint Committee on Administrative Rules recommendation; the Board agrees to open Subdocket B to consider groundwater monitoring August 23, 2012. I served as a panel witness to support the need for groundwater monitoring.

IN THE MATTER OF COMBUSTION WASTE (CCW) SURFACE IMPOUNDMENTS AT POWER GENERATING FACILITIES: PROPOSED (35 ILL. ADM. CODE 841), R14-10 (Rulemaking) Subject: Illinois EPA proposed a rule of is of general culpability that covers all coal combustion waste surface impoundments and power generating facilities in the State of Illinois. The proposed rules included provisions for: groundwater monitoring, weekly inspection, annual reports, preventive response, corrective action, and closure. I am serving as Illinois EPA's panel witness. June 13, 2014

KENNETH SHAW, and MARY CROSBY vs. VILLAGE OF SAUK VILLAGE Case No. 13 L004048 in Circuit Court of Cook County. (Enforcement) Subject: I was called as a witness by the plaintiffs to testify about drinking water regulations and laws that apply to Sauk Village. October 28, 2014.

X. Publications Authored or Co-authored

Cobb, R.P., 1980. ***Petrography of the Houx Limestone in Missouri***. Transactions of the Illinois Academy of Science Annual Conference, Illinois Wesleyan, Bloomington, IL.

A Plan for Protecting Illinois Groundwater, 1986, Illinois Environmental Protection Agency, January. 65 p.

Cobb, R.P., and Sinnott, C.L., 1987. ***Organic Contaminants in Illinois Groundwater***. Proceedings of the American Water Resources Association, Illinois Section, Annual Conference, Champaign, IL, April 28-29, p. 33-43.

Clarke, R.P., and Cobb, R.P., 1988. ***Winnebago County Groundwater Study***. Illinois Environmental Protection Agency. 58 pp.

Groundwater in Illinois: A Threatened Resource, A Briefing Paper Regarding the Need for Groundwater Protection Legislation, April 1987, Governors Office and Illinois Environmental Protection Agency, 34 pp.

Clarke, R.P., Cobb, R.P. and C.L. Sinnott, 1988. ***A Primer Regarding Certain Provisions of the Illinois Groundwater Protection Act***. Illinois Environmental Protection Agency. 48 pp.

Cobb, R.P., et al, 1992. ***Pilot Groundwater Protection Needs Assessment for the City of Pekin***. Illinois Environmental Protection Agency. 111 pp.

Cobb, R.P., 1994. ***Briefing Paper and Executive Summary on the Illinois Groundwater Protection Act and Groundwater Protection Programs with Recommendations from the Illinois Environmental Protection Agency Regarding***

the Siting of a Low Level Radioactive Waste Site. Presented to the Low Level Radioactive Waste Task Force on December 9, 1994 in Champaign-Urbana.

Cobb, R.P., 1994. ***Measuring Groundwater Protection Program Success.*** In the proceedings of a national conference on Protecting Ground Water: Promoting Understanding, Accepting Responsibility, and Taking Action. Sponsored by the Terrene Institute and the United States Environmental Protection Agency in Washington D.C., December 12-13, 1994.

Cobb, R.P., Wehrman, H.A., and R.C. Berg, 1994. ***Groundwater Protection Needs Assessment Guidance Document.*** Illinois Environmental Protection Agency. +94 pp.

Cobb, R.P., and Dulka, W.A., 1995. ***Illinois Prevention Efforts: The Illinois Groundwater Protection Act Provides a Unified Prevention-Oriented Process to Protect Groundwater as a Natural and Public Resource,*** The AQUIFER, Journal of the Groundwater Foundation, Volume 9, Number 4, March 1995. 3pp.

Cobb, R.P., 1995. ***Integration of Source Water Protection into a Targeted Watershed Program.*** In the proceedings of the Ground Water Protection Council's Annual Ground Water Protection Forum in Kansas City Missouri.

Dulka, W.A., and R.P. Cobb, 1995. ***Grassroots Group Forges Groundwater Protection Law.*** American Water Works Association, Opflow, Vol. 21 No. 3. 2pp.

Cobb, R.P., 1996. ***A Three Dimensional Watershed Approach: Illinois Source Water Protection Program.*** In the proceedings of the Ground Water Protection Council's Annual Ground Water Protection Forum in Minneapolis Minnesota.

Cobb, R.P., and W.A. Dulka, 1996. ***Discussion Document on the Development of a Regulated Recharge Area for the Pleasant Valley Public Water District.*** Illinois Environmental Protection Agency. pp 28.

Cobb, R.P., 1996. ***Illinois Source Water Protection Initiatives-Groundwater Perspective.*** In the proceedings of the American Water Works Association's Annual Conference and Exposition in Toronto Canada. pp 585- 594.

Cobb, R.P., and Dulka, W.A., 1996. ***Illinois Community Examines Aquifer Protection Measures.*** American Water Works Association Journal. p10.

Cobb, R.P., etal. October 1999, ***Ground Water Report to Congress,*** United States Environmental Protection Agency.

Cobb, R.P., December 2001. ***Using An Internet Geographic Information System (GIS) to Provide Public Access to Hydrologic Data***, Association of Groundwater Scientists and Engineers, National Groundwater Association, National Conference Proceedings, Nashville, Tennessee.

Cobb, R.P., September 2001, ***Regulated Recharge Area Proposal for the Pleasant Valley Public Water District***, Ground Water Protection Council Annual Forum Proceedings, Reno Nevada, 13 pp.

Wilson, S., Cobb, R.P., and K. Runkle, January 2002. ***Arsenic in Illinois Groundwater***. Illinois State Water Survey, Illinois Environmental Protection Agency, and Illinois Department of Public Health.
<http://www.epa.state.il.us/water/groundwater/publications/arsenic/index.html>, 7 pp.

R.P., Cobb, August 2002, ***Development of Water Quantity Planning and Protection in Illinois – A New Direction***, Proceedings of the Annual Ground Water Protection Council Technical Forum, San Francisco, California, 10pp.

P.C. Mills, K.J. Halford, R.P. Cobb, and D.J. Yeskis, 2002. ***Delineation of the Troy Bedrock Valley and evaluation of ground-water flow by particle tracking, Belvidere, Illinois***, U.S. Geological Survey Water-Resources Investigations Report 02-4062, 46 pp.

Illinois Environmental Protection Agency's ***Homeland Security Strategy***, March 2003, 20pp.

Illinois Environmental Protection Agency' ***Strategic Plan***, Bureau of Water Section, September 2003, pp.

Opinions and Conclusions of Richard Cobb for the Matter of People v. Peabody Coal, PCB 99-134 (Enforcement), May 23, 2003. 60 pp.

Cobb, R.P., Fuller, C., Neibergall, K., and M. Carson, February 2004. ***Community Water Supply Well Shooting/Blasting near the Hillcrest Subdivision Lake County, Illinois Fact Sheet***. Illinois Environmental Protection Agency. 4 pp.

Cobb, R.P. and J. Konczyk, June 2011, ***McCullom Lake Evaluation Report***, Illinois Environmental Protection Agency, 39 pp.,
<http://www.epa.state.il.us/water/groundwater/publications/mccullom-lake-evaluation-rpt.pdf>

Mills, P.C., and Cobb, R.P, 2015, ***Hexavalent and total chromium at low reporting concentrations in source-water aquifers and surface waters used for public***

supply in Illinois, 2013: U.S. Geological Survey Scientific Investigations Report 2015–5020, 58 p., <http://dx.doi.org/10.3133/sir20155020>.

XI. Additional Legislative Publications that I Participated in Developing

A Plan for Protecting Illinois Groundwater, Illinois Environmental Protection Agency, January 1986. 65 p.

Groundwater in Illinois: A Threatened Resource, A Briefing Paper Regarding the Need for Groundwater Protection Legislation, Governors Office and Illinois Environmental Protection Agency, April 1987. 34 pp.

Illinois Groundwater Protection Act, Public Act 85-0863, September 1987. 68 pp.

Public Act 92-0132 (***MTBE Elimination Act***), July 24 2001.

Executive Order #5 - requires the ICCG to designate a subcommittee to develop an integrated groundwater and surface water resources agenda and assessment report. The report shall analyze the burden's on Illinois finite water resources, quantify Illinois' water resources, and prioritize an agenda to plan for the protection of these water resources. The Director of the Department of Natural Resources chaired this subcommittee. The ICCG and GAC shall use the subcommittee's agenda and report to establish a water-quantity planning procedure for the State. The Governor signed executive order #5 on Earth Day April 22, 2001.

Amendments to Sections 2, 3 and 4 of the Illinois Groundwater Protection Act 415 ILCS 55/2 to establish a Groundwater and Surface Water Quantity Protection Planning Program, January 2002, 3 pp. These amendments were never adopted due to opposition from the Illinois Farm Bureau.

Public Act 92 –652 (Senate Bill 2072)- Amends the Illinois Groundwater Protection Act to require the Environmental Protection Agency to notify the Department of Public Health, unless notification is already provided, of the discovery of any volatile organic compound in excess of the Board's Groundwater Quality Standards or the Safe Drinking Water Act maximum contaminant level. The Governor signed this into law as Public Act 29-652 (effective July 25, 2002).

House Bill 4177 - Amends the Illinois Groundwater Protection Act. Provides that before property that has a well used for drinking water on it can be sold, the owner must have the well water tested for volatile organic chemical groundwater contaminants. Provides that if the well water does not meet the Illinois Pollution Control Board's Groundwater Quality Standards (35 Il Adm Code Part 620), the owner shall notify the Illinois Department of Public Health (IDPH) and the prospective buyer of the property. The realtors association July 2002 opposed House Bill 4177.

House Resolution 1010 - The resolution drafted by in cooperation with Senator Patrick Dunn' staff urge the Illinois Environmental Protection Agency to further strengthen its public outreach efforts by developing, after negotiations with individuals representing areas affected by contamination and other relevant State agencies, a procedure to notify property owners whenever the Agency has confirmed an exceedence of applicable health and safety standards, using scientifically credible data and procedures under Illinois regulations. HR 1010 was adopted by voice vote on June 1, 2004.

Public Act 94-314 (Senate Bill 0214) – This is referred to as Right-to-Know (RTK) law. The law includes providing the Illinois EPA with administrative order authority (AO), information order authority, and established the requirements for providing notices to residents or business exposed or potentially exposed to contamination. The Illinois EPA had been seeking this type of AO authority for the past 35 years. Senate Bill 0214 was unanimously passed by both the Senate and the House May 2005. The legislation was signed into law by the Governor July 27, 2005.

Public Act 94-849 (House Bill 1620) - Amends the Environmental Protection Act. Requires the owner or operator of a nuclear power plant to report to the Environmental Protection Agency any unpermitted release of a contaminant within 24 hours. The bill was signed by the Governor on June 12, 2006.

Public Act 96-0603 (Crestwood Bill) - Amends the Environmental Protection Act. This law requires the owners and operators of community water systems to maintain certain documents and to make those documents available to the Agency for inspection during normal business hours. Provides that the Agency shall provide public notice within 2 days after it refers a matter for enforcement under Section 43 or issues a seal order under subsection (a) of Section 34. Further, the bill provides that the Agency must provide notice to the owners and operators of the community water system within 5 days after taking one of these actions. Moreover, the bill requires that within 5 days after receiving that notice, the owner or operator of the community water system must send a copy of the notice to all residents and owners of premises connected to the community water system. In addition, indirect notification of institutional residents is provided. Requires the owner or operator of the community water system to provide the Agency with proof that the notices have been sent. Sets forth similar notice requirements that must be complied with when groundwater contamination poses a threat of exposure to the public above the Class I groundwater quality standards. The bill creates a civil penalty for violations of these notice requirements, and makes it a felony to make certain false, fictitious, or fraudulent statements. The bill passed both houses on May 30, 2009. The bill was sent to the Governor for signature on June 26, 2009, and was signed into law on August 24, 2009.

Public Act 096-1366 – Amends the Environmental Protection Act. This new law requires public water supplies to submit a corrective action plan to the Illinois EPA upon the Agency's issuing a right-to-know notice upon verifying that the finished public water

has in fact exceeded 50% of the MCL for carcinogenic VOCs. Requires the response plan to include periodic sampling to measure and verify the effectiveness of the response plan, but also requires the Illinois EPA to take into account the technical feasibility and economic reasonableness of the response plane in approving, modifying, or denying the response plan. Signed into law on July 28, 2010; effective July 28, 2010.

**APPENDIX II – Geologic Well Logs of the McHenry County Conservation District
Irrigation Wells (North and South)**

MCCD IR N

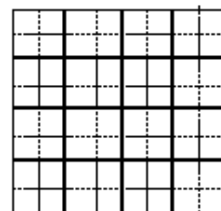
Page 1 ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
sandy loam	0	2
fine sand	2	10
fine sand and gravel	10	24
coarse sand and gravel	24	33
gravel and small boulders	33	55
Interpretation by: S. Specht on 01-FEB-76		
Sandy silt loam, (loess and sand) non-calcareous, much organics, black	0	8
Sand and gravel, clean, sand=medium to coarse grained; gravel=medium to coarse	8	40
Gravel, coarse, clean	40	55
Total Depth		55
Casing: 18" CONCRETE from 0' to 55'		
Screen: 28' of 18" diameter .18 slot		
Pumping level 12' when pumping at 1000 gpm for 5 hours		
Driller's Log filed		
Sample set # 49705 (5' - 55') Received: July 14, 1964		
Owner Address: ,		
Location source: Location from the driller		

Permit Date:

Permit #:

COMPANY Brown Irrigation Co.
 FARM Kerber Packing Company
 DATE DRILLED January 1, 1963 NO. 2
 ELEVATION 795GL COUNTY NO. 00887
 LOCATION 2640'N line, 1320'W line of NW
 LATITUDE 42.262348 LONGITUDE -88.642574
 COUNTY McHenry API 121110088700



27 - 44N - 5E

MCCD IR S

Page 1 ILLINOIS STATE GEOLOGICAL SURVEY

Water Well	Top	Bottom
sandy loam	0	3
fine sand	3	26
coarse sand & gravel	26	35
gravel & small boulders	35	55
Interpretation by: S. Specht on 01-FEB-76		
Sand, medium to fine, some gravel, few silt, no clays, soil modification, non-calcareous and loess	0	5
Sand and gravel, sand is medium to coarse, clean, no silt or clay, non-calcareous	5	30
Gravel, medium to coarse, with some sand, clean	30	50
Total Depth		55
Casing: 18" CONCRETE from 0' to 55'		
Screen: 28' of 18" diameter .18 slot		
Static level 12' below casing top which is ' above GL		
Pumping level 17' when pumping at 900 gpm for 5 hours		
Driller's Log filed		
Survey Sample Study filed		
Sample set # 49700 (5' - 50') Received: July 14, 1964		
Owner Address: ,		
Location source: Location from the driller		

Permit Date:

Permit #:

COMPANY Brown Irrigation Co.

FARM Kerber Packing Company

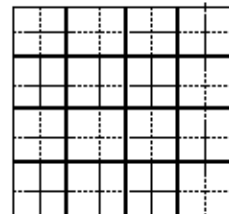
DATE DRILLED January 1, 1963 NO. 1

ELEVATION 797TM COUNTY NO. 00888

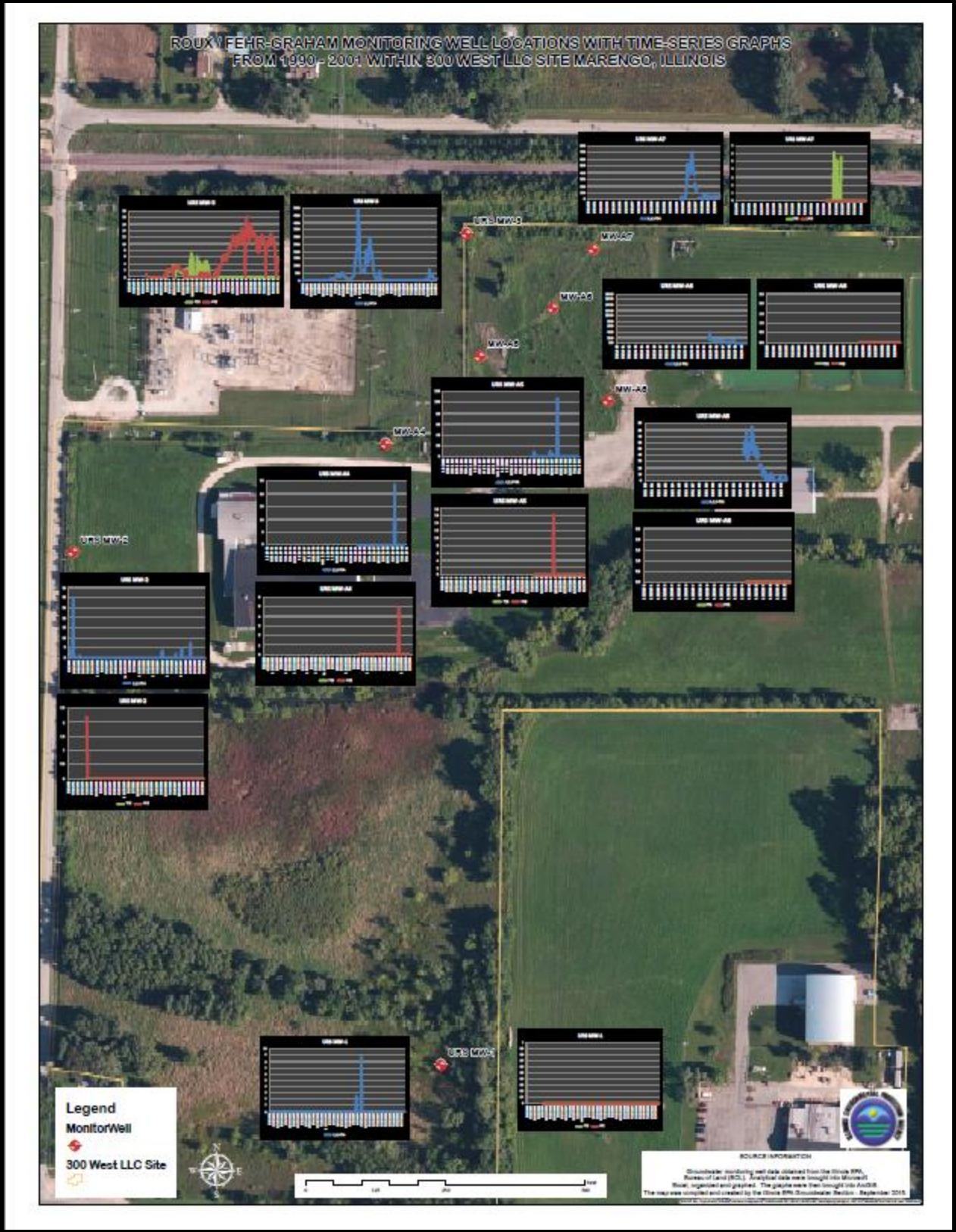
LOCATION 50'N line, 1320'W line of NW

LATITUDE 42.254926 LONGITUDE -88.642549

COUNTY McHenry API 121110088800 34 - 44N - 5E



APPENDIX III - Map of Roux (1990) and Fehr-Graham (2001) On-Site Groundwater Monitoring Network and Associated Time Series Graphs of VOC Contaminants



APPENDIX IV – MW 31 and GP 106



Illinois Environmental Protection Agency

Well Completion Report

Site Number: _____ County: McHenry

Site Name: Arnold Engineering Co.

Well #: MW-31

State _____
Plane Coordinate: X _____ Y _____ (or) Latitude: _____ Longitude: _____

Borehole #: _____

Surveyed by: B. Lennon

IL Registration #: _____

Drilling Contractor: Earth Solutions

Driller: _____

Consulting Firm: EGSL

Geologist: S. Boom

Drilling Method: Hollow Stem Auger

Drilling Fluid (Type): N/A

Logged By: _____

Date Started: _____ Date Finished: _____

Report Form
Completed By: S. Boom

Date: 11/7/2013

ANNULAR SPACE DETAILS

Type of Surface Seal: Concrete

Type of Annular Sealant: Bentonite (Hydrated)

Installation Method: Bottom Up

Setting Time: 24 Hours

Type of Bentonite Seal - - Granular, Pellet, Slurry
(Choose One)

Installation Method: Bottom Up

Setting Time: 24 Hours

Type of Sand Pack: 20-40 Sand

Grain Size: 20-40 (Sieve Size)

Installation Method: Hollow Stem Auger

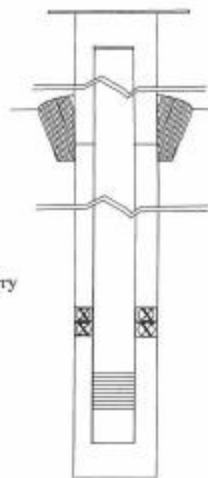
Type of Backfill Material: N/A
(if applicable)

Installation Method: N/A

WELL CONSTRUCTION MATERIAL

(Choose one type of material for each area)

Protective Casing	SS304, SS316, PTFE, PVC, or Other
Riser Pipe Above W.T.	SS304, SS316, PTFE, PVC, or Other
Riser Pipe Below W.T.	SS304, SS316, PTFE, PVC, or Other
Screen	SS304, SS316, PTFE, PVC, or Other



Elevations (MSL)*	Depths (BGS)	(.01ft.)
820.860	0.10	Top of Protective Casing
820.28	-0.48	Top of Riser Pipe
820.760	0.00	Ground Surface
819.760	-1.00	Top of Annular Sealant
799.460	-21.30	Static Water Level (After Completion)
819.760	-1.00	Top of Seal
812.760	-8	Top of Sand Pack
810.760	-10	Top of Screen
790.860	-30	Bottom of Screen
790.860	-30	Bottom of Well
790.860	-30	Bottom of Borehole




* Referenced to a National Geodetic Datum

CASING MEASUREMENTS

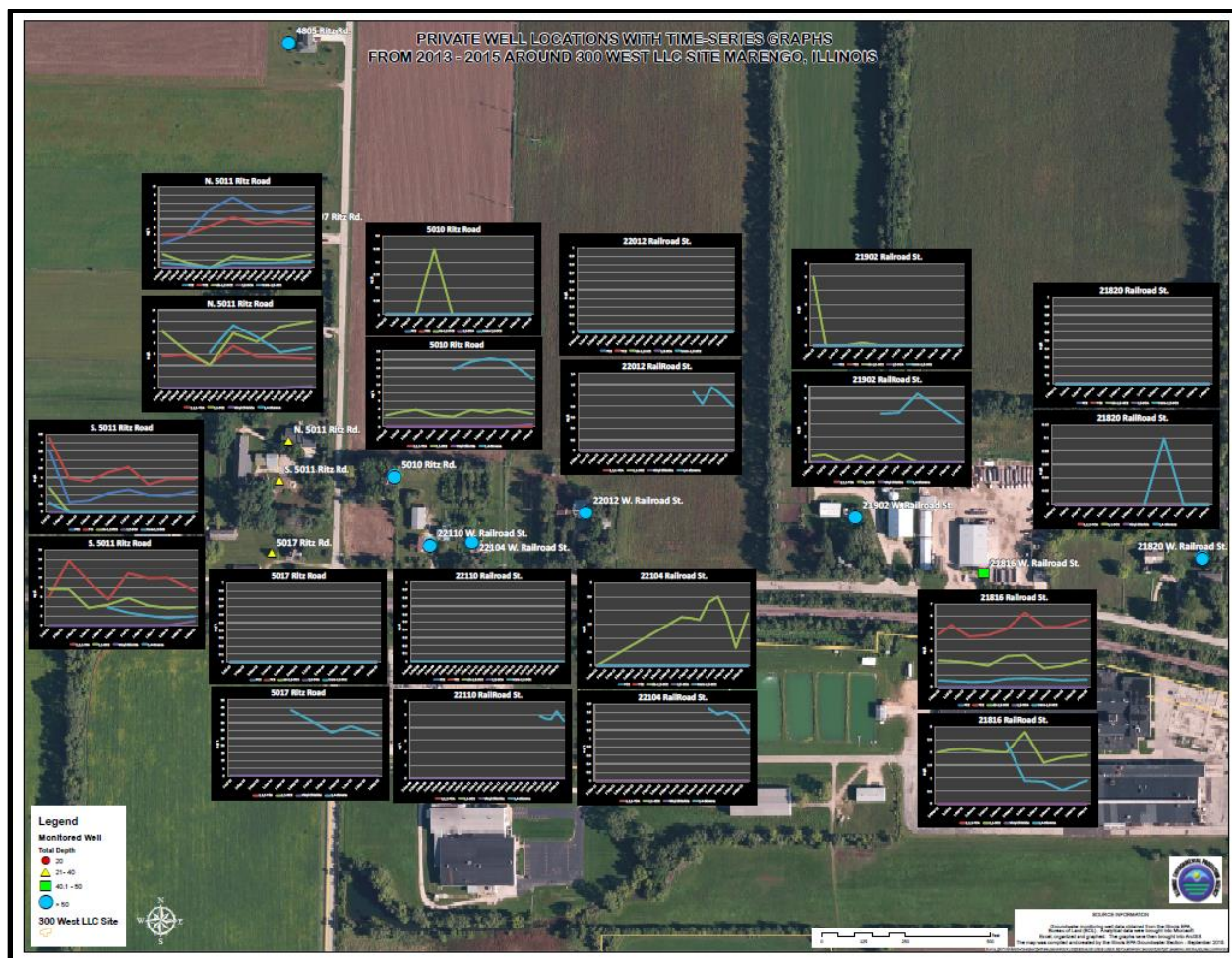
Diameter of Borehole (inches)	5.75
ID of Riser Pipe (inches)	3.0
Protective Casing Length (feet)	1.0
Riser Pipe Length (feet)	44.52
Bottom of Screen to End Cap (feet)	0.50
Screen Length (1" slot to 1st slot) (feet)	4.5
Total Length of Casing (feet)	45
Screen Slot Size **	#10

**Hand-Slotted Well Screens are Unacceptable

Well Completion Form (revised 02/06/02)

 ENVIRONMENTAL GROUP SERVICES LIMITED 557 W. Polk Street Chicago, IL 60607					Soil Boring Log		Boring Number: GP-106
Subject Property 300 West Street Marengo, IL					Soil Boring Date 09/04/13		
PID (ppm)	Sample Recovery (%)	Sample	Depth (feet)	General Soil Class	Lithology	Description	Notes
1.8	90		0.0	Soil		Black organic topsoil.	
			1.0	Sand		Brown grey coarse sand. Pebbles.	
			2.0				
2.3	90		3.0				
			4.0				
			5.0				
			6.0				
			7.0				
0.0	90		8.0				
			9.0				
			10.0				
			11.0				
			12.0				
			13.0	Silt		Brown grey sandy silt	
			14.0	Clay		Brown sandy clay	
		15.0					
			16.0	Clay		Brown sandy clay. Wet.	
		17.0					
Key:  Sample Submitted for Analysis  Sample on Hold at Laboratory							Drill Rig: Geoprobe 6610DT
							Driller: Earth Solutions, Inc.
Boring Depth: 15 feet Groundwater Depth: 13 feet							Geologist: S. Boom

**APPENDIX V – Map of Private Water Supply Wells and Associated Time Series
Graphs of VOC and 1,4 D Contaminants**



APPENDIX VI – MW 83/84 - GP 394

Weaver Consultants Group North Central, LLC				File: 3892-300-03		
ENVIRONMENTAL & GEOTECHNICAL CONSULTANTS				Log of Soil Boring: GP-394 (0-50') associated with MW-84		
WATER LEVEL DATA		Started:	3/9/2015		Client: 300 West, LLC.	
12 Ft WHILE DRILLING		Completed:	3/9/2015			
Ft AT COMPLETION		Driller:	Cabeno			
Ft AT _____ HOURS AFTER DRILLING		Helper:				
		Location:	Marengo, Illinois		See Sketch	
SAMPLE DATA						
DEPTH (ft)	STRATA DEPTH/SOIL DESCRIPTION	SAMPLE NO.	RECOVERY (in.)	PID VALUE	Qp (tsf)	WATER CONTENT
1.0	Dark brown, medium, sandy clay, with organics, some gravel, well sorted	GP-394 (1-3')		0.3		DRY
2.0	Dark brown, lean clay			0.3		DRY
	Brown lean clay, with some gravel, well sorted					DRY
3.0	Brown, medium, sandy clay, with gravel, well sorted			0.2		DRY
4.0	No Recovery			NA		N/A
5.0				NA		
6.0	No Recovery			NA		N/A
7.0	Brown, clayey, medium sand, with gravel, well sorted			0.3		DRY
8.0	Brown/gray, medium sand, with white coarse gravel, well sorted			0.1		DRY
9.0	Light brown, very fine clayey sand, with fine gravel, well sorted			0.2		DRY
10.0	Light brown, medium sand, mixed clay			0.1		DRY
11.0	Brown/gray, medium sand, with gravel, well sorted			0.2		MOIST
12.0				0.1		
13.0	Red/brown, fine sandy clay			0.2		WET
14.0	Light brown, medium sand, well sorted			0.2		WET
15.0				0.3		
16.0	No Recovery			NA		N/A
17.0				NA		
18.0	Light brown, medium to coarse sand, well sorted			0.2		WET
19.0		GP-394 (18-20')		0.2		WET
20.0	Yellow, well sorted, gravel			0.4		WET
21.0	Light brown/red, very fine sand, well sorted			0.1		WET
22.0				0.1		
23.0	No Recovery			NA		N/A
24.0				NA		
25.0				NA		

Weaver Consultants Group North Central, LLC				File: 3892-300-03		
ENVIRONMENTAL & GEOTECHNICAL CONSULTANTS				Log of Soil Boring: GP-394 (0-50')		
WATER LEVEL DATA		Started: 3/9/2015		associated with MW-84		
13 Ft WHILE DRILLING		Completed: 3/9/2015		Client: 300 West, LLC		
Ft AT COMPLETION		Driller: Cabeno		See Sketch		
Ft AT _ HOURS AFTER DRILLING		Helper:				
		Location: Marengo, Illinois				
		SAMPLE DATA				
DEPTH (ft)	STRATA DEPTH/SOIL DESCRIPTION	SAMPLE NO.	RECOVERY (in.)	PID VALUE	Qp (tsf)	WATER CONTENT
26.0	No Recovery			NA		N/A
27.0				NA		
28.0				0.6		
29.0	Gray/brown, coarse sand, with many gravel, well sorted			0.8		WET
30.0	Dark gray, medium sand, with gravel, well sorted			0.3		
31.0	No Recovery			NA		N/A
32.0				NA		
33.0	Gray/brown, coarse to medium sand, with many gravel, well sorted			1.2		WET
34.0				0.5		
35.0				0.4		
36.0	Gray, medium sand, with some gravel, well sorted			0.1		WET
37.0				0.1		
38.0				0.4		
39.0	Gray, fine sand, well sorted			0.8		WET
40.0				0.9		
41.0	Brown/gray, fine sand, well sorted with some gravel			0.0		WET
42.0				0.0		
43.0	Brown/gray fine to medium sand, well sorted			0.1		WET
44.0				0.4		
45.0				0.1		
46.0	No Recovery			NA		N/A
47.0				NA		
48.0				NA		
49.0				NA		
50.0				NA		

NOTES:

**APPENDIX VII – Map of Private and Monitoring Wells Centric to 300 West and
Associated Snap Shot of VOC and 1,4 D Contaminant Data**

